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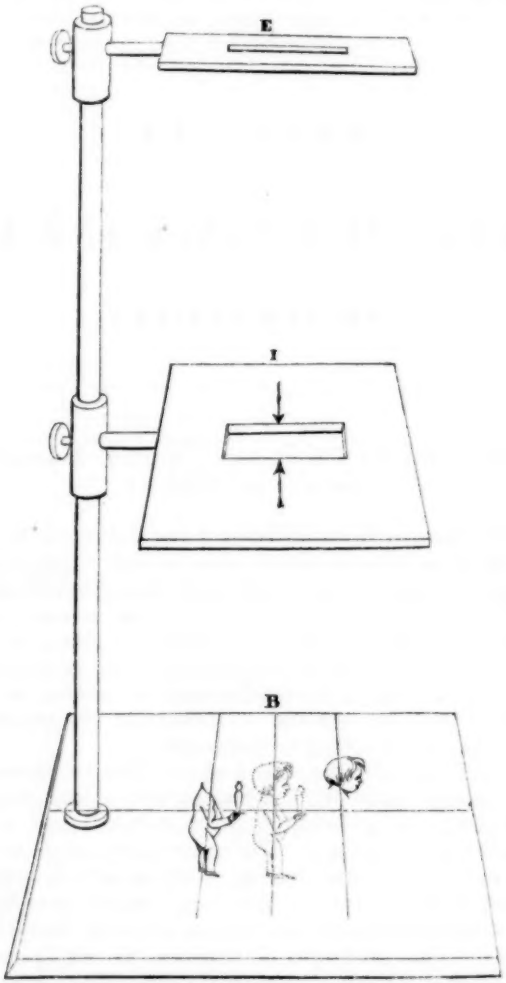
[SECOND SERIES.]

Art. XVII.—*On the Phantascope;* by Prof. J. Locke. (In a Letter to the Editors.)

As many persons find it difficult if not impossible to converge the optical axes, (or in common phrase to look "cross-eyed,") for the purpose of making the experiments lately described by me, under the head of "binocular vision," I have invented an instrument which enables all persons to succeed in obtaining the chief results. It is very simple, having neither lenses, prisms nor reflectors, the object being in general the same as holding the finger or other object near the eyes and concentrating the attention upon it for the purpose of optical convergence.

It consists of a flat base-board about nine by eleven inches, with an upright rod at one end bearing two sliding sockets to be clamped at any elevation like those of a retort stand, or adjustable by stiff sliding springs. The upper socket supports horizontally a small vane or card, having a slit or sight hole one fourth of an inch wide and three inches long from right to left. This slit has its middle directly over the center of the base-board, and is intended to have the eyes directly over it, one eye at one end and the other at the other;—two small holes, say one fourth of an inch, occupying the place of the ends of this slit would answer, except for the unequal distances between the eyes of different observers. The lower of the two sockets bears horizontally a movable screen of pasteboard or thin wood, having a slit at least three inches wide from left to right, and about one inch in the other

direction, with its center also perpendicular over the center of the base-board. This screen has marked vertically across its middle an index, shown by two arrows in the figures marked I.



E. Eye screen.—I. Index screen.—B. Base-board.

Experiments.—In experimenting with the Phantascope, the operator places whatever is to be tried upon the lower tabular base-board, looks downward through the upper slit and slides the screen up or down until he attains the adjustment required.

Exp. 1.—Let there be two identical letters, say A, placed or drawn on the base-board about two and a half inches apart from left to right, let the movable screen be nearly down, and directing the eye not to the letters, but to the index, draw the sliding screen bearing the index gradually upward; the two letters seen indirectly, will appear as four; or each letter will be double AA AA; continuing to raise the screen and to regard the index, the double images will recede more and more until their position will be thus A A A A; continuing still to raise the screen, the two internal images approach until they are optically superimposed and coalesce into one, thus;

A A A

This middle or superimposed figure, is the phantom or image where there is really no object. Cease to look at the index I, and turn the attention to the base-board itself, and this phantom figure instantly vanishes. If the two letters be placed on the base-board at the same distance as the eyes are apart, say two and a half inches, then this normal position of the screen will be just half way between the eyes and the base-board. If they are placed further apart, the screen must be raised higher; the distance from the eyes to the index screen being in all cases, to the distance from that screen to the base-board, as the distance between the eyes is to the distance between the objects viewed. In the case above, the phantom image is formed exactly as if there were a letter in the area of the index screen of half the size of the primitive letters on the base-board, and optically the letter should appear then, but the knowledge of the observer that there is nothing at that place, will often prevent the deception.

Exp. 2.—Lay upon the base board a card having letters or other figures which are identical in size and form set in regular rows and at equal distances all over, thus:

A A A A A A

A A A A A A

A A A A A A

and proceed to raise the screen as before; you will form phantom images as before between each of these figures, or possibly you will superimpose the first object upon the third, when you will have, not a single phantom but a whole plane of them, each pair presenting a phantom between. This phantom surface will be likely to effect a complete deception, and will rise from the base-board and coincide with the index plane, when it may be contemplated with the same deliberation and ease to the eyes, as if it were a real object. This would be sure to be the case if the index plane were figured over in the same manner, but with figures properly reduced in size.

Exp. 3.—Place two identical pictures of the same flower on the base-board, say they are an inch in diameter, and two and a half inches apart; place also on the edge of the index area, a picture of a small flower pot or vase, with flower stems as an index; then form the phantom image as before, and the flowers will appear in the vase so long as you contemplate the stems at the index screen, but the moment the eyes are directed to the flowers themselves, the phantom vanishes.

Exp. 4.—Let one of the above flowers be red and the other blue; the phantom will be purple. Sometimes however it will appear nearly red and then again blue. This and some other experiments, convince me that the attention of the mind even when we are looking with both eyes, is often directed exclusively to the image in one eye, and perhaps after that tires, the image in the other is contemplated. If this be true, then the two eyes serve in the first place to fix the distance of an object by the amount of convergence, and in the next place to relieve each other by turns.

Exp. 5.—Let there be a horizontal heavy line placed to the left and a vertical one to the right on the base-board, thus: — |, then adjust the screen and superimpose the images to form a phantom. That phantom will be a cross and the whole will appear thus: — + |

Exp. 6.—Do the same with any other parts of a figure of which one shall be the complement of the other; the phantom will be the complete figure. Thus take the picture of a person, cut it out of the paper, and cutting off the head, place the body on one side of the base-board, and the head upon the other, the converged phantom will be the complete figure, the head coming in from one side and the body from the other. It is perhaps unnecessary to say that each part must be placed in its true elevation, though displaced horizontally. It was in repeating this experiment, that I discovered that my eyes did not appear to be mates, for I saw the body clearly but the head obscurely. After a little time however, these conditions interchanged, and I saw the head clearly and the body obscurely. Nor did I seem to have any voluntary control over these conditions, but my eyes continued to relieve guard according to some rule of their own. This is rather an amusing experiment: the figure being beheaded, the phantom ghost appears between the two parts of the body, and from a little unsteadiness of the optical convergence, the ghost's head is inclined to attitudinize, and will sometimes start off a little from the body, and in returning, will go a little too far and will break the neck in the opposite direction. If the head of the experimenter be a little inclined, then the head of the phantom will come on too high or too low.

Exp. 7.—I placed a card having two perpendicular parallel lines about two inches in length and three inches apart. On converging them in an attempt at superposition, I found the converged lines were not parallel but came in contact at the upper end first, and diverged a little downward. Standing with my head erect, I repeated this experiment by converging voluntarily and without the aid of any index, the parallel sides of a window; the same want of parallelism was exhibited, but on throwing my head backward and looking horizontally over my cheeks, the converged perpendiculars coincided throughout. I learned by this that both of my eyes do not rotate in one and the same horizontal plane. I got another person to repeat the same experiment, and he found the error of his eyes to be in the opposite direction, the converged perpendiculars meeting first at the bottoms. This proves a moral adage to be physically true, "we don't all see alike."

This instrument and the researches into binocular vision, serve to extend considerably our knowledge of the anatomy and physiology of vision, nor is the subject by any means exhausted. I have not time to investigate the matter fully, and shall be happy to see fair and honorable competitors enter the field. The verifications and variations of the experiments by your correspondent, Dr. Lathrop, were gratifying to me.

This apparatus will illustrate many important points in optics, and especially the physiological point of "single vision by two eyes." It shows also that we do not see an *object* in itself, but the mind contemplates an image on the retina, and always associates an object of such a figure, attitude, distance, and color as will produce that image by rectilinear pencils of light. If this image on the retina can be produced without the object, as in the Phantascope, then there is a perfect optical illusion, and an object is seen where it is not. Nay, more, the mind does not contemplate a mere luminous image, but that image produces an unknown physiological impression on the brain. It follows that if the nerves can, by disease or by the force of imagination, take on this action, a palpable impression is made without either object or picture. As this would be most likely to occur when actual objects are excluded, as in the night, we have an explanation of the scenery of dreams, and the occasional "apparitions" to waking persons. The murderer, too, has a picture stamped on the sensorium by the sight of his victim, which ever wakes into vibration when actual pictures are excluded by darkness.

ART. XVIII.—*The condition of Trap dikes in New Hampshire an evidence and measure of Erosion;* by OLIVER P. HUBBARD, M.D., Prof. Chem., Min. and Geol., in Dartmouth College.

IN New Hampshire, whose geology is characterized chiefly by primary rocks and metamorphic slates—trap dikes are exceedingly numerous, and they have an evident relation both in position and character to those of the adjoining states. Among them all, none have yet been described, (perhaps not observed,) that are eminent at all above the rocks enclosing them; and there is only one place where the bulk and prominence of the trap is such as to indicate a center of elevation, or greater resistance to erosion, than in the adjacent rock. This is the most northern of the peaks of Ossipee Mountain, east of Lake Winnipisiogee; it is described as "an isolated, bare, precipitous range of bluish greenstone rock," and abundant fragments are found on the adjoining peak, covering the gneiss. From this point as a center, series of dikes seem to radiate in various directions; one group east of Red Hill, ranging north 60° or 70° west, and varying from one to three or four feet in width; another similar one, west of Red Hill, near Squam lake, from one inch to ten feet wide, ranging east and west. "These dikes are distinctly marked over the surface of the granite including them. They have been worn and polished by the action of diluvial currents, so that a level and smooth surface, comprising many thousand square feet, lies entirely bare of soil."*

In volume xxxiv. of this Journal, (p. 105,) I have described a number of trap dikes, presenting the same relations to the enclosing rock, and without doubt there are hundreds of instances of the kind in New Hampshire and Vermont; and they are found at all levels, and continuous for considerable distances. The present condition of these dikes is, obviously, evidence of more or less erosion. I propose to cite in this paper, examples of trap dikes in New Hampshire and vicinity, which shall show how far they are *evidences and measures of erosion*, whether ancient or recent.

The trap in New Hampshire occurs in relation to the surrounding rocks either—1. *Worn off smooth and plane with the adjacent rock*, whether the surface be horizontal or inclined—2. *Below the surface*, when in a state of decomposition and forming, it may be, the channel of a stream—3. *Prominent above*, as at the Peak of Ossipee, and when forming an occasional barrier of a stream, where the surrounding rock has been removed.

There are believed to be very few instances of the third condition. Bear Camp river is crossed by a dike one to two feet

* Geology of New Hampshire, p. 72.

wide which forms a barrier, the granite having decayed away. There may possibly be an instance in Red Hill, where the dike is exposed on one (the lower?) side by the removal of the granite.*

(*a.*) Of the second kind, there is an example in the rear of† the Willey house, referred to by Mr. Lyell in his second tour, and described by me previously in volume xxxiv. of this Journal. The trap is the bed of a small mountain torrent, in some parts decomposing, in others very hard. This dike was traced this season by some members of our party,‡ along a continuous and deep channel far up the mountain, and it is there found to divide into two parts, which again meet a considerable distance above, and thus enclose a large elliptical area. This area is distinctly observable from the house below, as it is fringed with a vivid green of deciduous shrubs, which mark the water courses in the mountains. As there must have been a time when the channel had no existence, and the trap filled it, up to the plane of the mountain, the formation of the water course may fairly be attributed to the decomposition of the dike, and the *depth* of the channel is evidently a measure of the erosion.

(*b.*) The "Flume," in the "Franconia Notch," is a deep chasm ten to sixteen feet wide, "having mural precipices of (very hard) granite on each side," forty to sixty feet high, while a mountain torrent rushes through it at high water. I saw it last June, after a severe drought of some weeks; there was but little water, and no difficulty in ascending it with occasional wading, and climbing over the large angular and rounded rocks in the way. The direction of the channel is north 80° east. At its lower end on the right hand is a trap dike, in several distinct lines each a few inches wide, mounting high in curved plates in the side of the cliff; farther on they decline and coalesce into *one* dike twenty inches wide, which passes under the water.

The dike crosses the fissure obliquely at about N. 75° E., and is seen some rods farther up the stream in a vertical section extending to the top of the opposite bank.

The trap where constantly wet is softened and decomposing, and above on the sides, is compact, very much fissured and stained deep with oxyd of iron. This fissure, like the former, must be admitted to have been filled by the intrusion of trap, and to have become a water channel by the removal of the dike; the channel, therefore, is some measure of the erosion of the trap and its rocky enclosures by existing agency.

(*c.*) The description given in the Geology of New Hampshire of the beautiful Dixville Notch, in the northern part of the state, suggests similar conclusions.

* A.m. Jour. Sci., vol. xxxiv, p. 113. † Ibid, p. 111.

‡ Members of the Senior Class in Dartmouth College.

"The summit of the (new) road (passing through the Notch to Portland, Maine,) is 835 feet above the plain of Colebrook. The direction of the pass is N.E. and S.W., and it is walled on both sides by towering ledges and pinnacles of mica slate, which stand nearly vertical, dipping to the N.W. 80°, and attain an elevation of 600 to 800 feet from the road"—of course about 1600 feet above Colebrook; and the Notch is parallel to the direction of the strata, which clearly have been removed on this line. Can we discover any disturbing agency or predisposing cause for this depression, from the summit of which the streams flow either way into the Androscoggin and the Connecticut? We learn that "dikes of basaltiform trap intersect the strata near the middle (summit?) of the Notch, and large loose blocks of it are seen in abundance on its northwest side. It contains very large crystals of basaltic hornblende and glassy white feldspar." The course of these dikes is not given. "On the north side of this road, forty or fifty rods back in the forest, is a ravine called 'the Flume.' It was formed by the decay of a large trap dike." "The chasm is twenty feet deep and from ten to twenty feet wide, and is the channel of a stream of water, from whence it received its name. The trap dike runs N. 30° E., and S. 30° W., and is six feet wide. It is slightly porphyritic with feldspar crystals, and is of a dark brown color. It divides into large cubical blocks which form a series of steps, so that when there is but little water a person may walk a considerable distance up the flume upon them. The principal ledge at this spot is granite, which protrudes through the mica slate."

Here we find a gorge through a mica slate range parallel with its direction N.E. and S.W., the slate dipping N.W. 80°, intersected by trap dikes—and near, another trap dike in a fissure, having the course N. 30° E., which is a variation of only 15° from the direction of the Notch, and all coincide in direction with the slate. But whether the different dikes are connected or not, erosion would seem to be indicated, down to the present level of the dikes, to the amount of 800 feet.

(*d.*) To cite one more case where the agent is still acting. The Waterqueechy river at Queechy village, (Hartford, Vt.,) makes a high fall of twenty feet over a dam of ten feet, and its rocky channel and sides are covered with pot-holes, and the gravel banks are here some eighty feet above with several terraces extending down a mile or more, where the narrow valley becomes a *cul de sac* from which the water could not have escaped before the present outlet existed, *except at a much higher level.** At this point the

* I am informed by the Rev. Mr. Dudley of the village, that between the gulf and the village there are two distinct deserted channels parallel to the present one, but much higher, where in all probability, the river once ran.

river enters a rocky channel, called "The Gulf," at a large angle with its previous course, and runs S.S.W. with a rapid descent for nearly a mile. The left bank (in the descent) is nearly vertical, though receding at top, and by estimate one hundred feet high, and the opposite bank, with various irregularities, is *in part* and in some places *entirely* made up of a *trap dike* from three to six and ten feet thick, whose course is N.N.E. and dip 58° southeasterly, and *coincident in these respects with the mica slate enclosing* and underlying it and parallel of course to the stream. It has here and there been crossed by the stream and extensively removed with the slate below it, and a channel has been made on both sides which is filled at high water; and again the dike is found enclosing the slate and is extremely hard and compact.

Passing off at right angles to this dike, as lateral branches, and crossing under the stream, are two other large vertical dikes which are very distinctly seen in section in the perpendicular wall of slate opposite, and they may be traced some distance easterly from the top of the bank, but are soon concealed by gravel and soil. One of these is twelve feet wide, of light blue color, and beautifully amygdaloidal, with numerous white crystallized balls.

These last dikes do not seem to have been injected subsequently to the first, but are so blended at their union with it, as to leave no doubt of their being one system, and a part of the trap network which extends through the region.

The pot-holes and troughs or elliptical holes, are very numerous throughout the channel as may be seen at low water, and they occur where there is no fall. They are produced by the action of a very rapid stream over an irregular surface. There can hardly be found a more satisfactory case of erosion by existing agencies. At the same time the trap dikes whose perpendicular section measures the extent of the specific action, indicate in their easterly extension, level with the surface of the enclosing rock of the bank above, the prevalence of earlier and more general superficial causes of denudation.

(*e.*) At the termination of the Mass. and Vt. Railroad near the Connecticut river bridge at Brattleboro, Vt., it was necessary to remove by blasting a large amount of slate rock, which was graded down about thirty feet to the level of the track, which is about thirty feet above the river. The whole of the surface of the rock laid bare, was very smooth, and worn into curves and channels and then scratched every where with strong marks, of varying north and south directions, parallel and crossing each other in groups. In this bank was a large trap dike thirty and more feet wide, whose surface was coincident with that of the slate and showed the same marks, continuous from one to the other.

The direction of the dike is about N.N.E. in a line with the bridge across the river, and it is quite probable the dike extends a long distance either way and was once a barrier to the river. The Connecticut river is here bounded on the east by a high rocky mountain, and the position and appearances of the dike in relation to the river, suggest the inference that the removal of the trap is a fair measure of the erosion at this place, and, at least in part, of that produced by the action of the river (sixty feet).

A small stream from the west in a deep rocky channel just north of the bluff removed, seems to have had its course deflected so as to empty into the Connecticut river just *north* of the intersection of the latter river and the dike, and their joint force has continued to reduce the level of the latter so as to afford the free passage of the river.

(*f.*) We may mention here, before proceeding, a few facts brought to light by the different railroad surveys in New Hampshire and Vermont. The Rutland and Burlington Railroad crosses the Green Mountains at Mount Holly gap, at a level of 1350 feet above the Connecticut river.* In this place a cut was made through a muck swamp, which exhumed some remarkable elephantine remains.† The White Mountain Railroad survey from the Connecticut up the Ammonoosuck, passes the summit in or near Whitefield, at six hundred and fifty feet above the Connecticut, and this within twelve miles of Fabyan's in the White Mountains. The Passumpsic Railroad overcomes the summit in Sutton at about nine hundred feet above the Connecticut at West Lebanon. The Central Railroad of Vermont passes the summit between the White and Winooski rivers near Montpelier, nine hundred and thirty feet above the Connecticut at West Lebanon. The Northern Railroad from Concord, New Hampshire, to the Connecticut, passes the summit between the Merrimack and Connecticut valleys, in Orange, with high grades of 52·80 feet in a mile on both sides, at an elevation of eight hundred and thirty feet above the Merrimack at Concord, and only six hundred and eighty-two feet above the Connecticut river on the west.

If at any time, by reason of the difference of level of these valleys of Connecticut and Merrimack rivers, water were discharged from one to the other for a long period through the lower passes, we should expect to have evidence of it engraved upon the rocks. If such evidences were discovered as we know from our running streams to be the effect of water, we shall be justified in referring them to a similar agency, i. e., water in motion. Should we observe phenomena like what are frequently seen, in the less rapid

* See profiles and reports of these roads.

† Agassiz. Proceedings Am. Assoc. for Adv. Science, held at Cambridge, September 1, 1849.

parts of a river and above dams in a rapid stream, we may refer their production to a similar cause.

The original features of this Orange summit were remarkable, but they have been very much altered by the cut for the railroad, which has however added, by the new features developed, very much to its geological interest. The facts have an important bearing on problems which are now arising with reference to the geological history of New England, and are therefore worthy of record. A description in part, is given by Dr. C. T. Jackson in the Geology of New Hampshire, p. 113.

The turnpike from Canaan on the northwest, passes some miles along the edge and on the sides of sand and gravel hills on the borders of an extensive swampy, peaty meadow, with a sandy bottom, which has long ramifications into the lateral valleys, then near a shallow pond of a few acres, which is fed by a rivulet coming from the hackmatac swamp at the base of the summit. The valley narrows rapidly, and towards the summit we find numerous long sand and gravel hills, shaped like an inverted boat, twenty to thirty feet high, parallel nearly to each other and to the general trend of the valley, with channels for surface water between them.

The depression or gap is several hundred feet below the general height of the range, and the old road formerly passed the summit at an elevation about forty feet above the swamp, and was made in the lowest channel cut by the waters formerly running here, and directly by the side of the "well"* made a slight descent across soft ground on a log causeway, then over a rocky ridge and down into Grafton valley.

This well or pot-hole, as figured, appears worn down on the side next the road three feet lower than on the opposite; its depth is eight feet; its diameter is between four and five feet at top, and about two feet at bottom. A large number of small, smooth rounded stones from this well, are in my possession, and in the Dartmouth cabinet is a plum shaped smooth mass of granite, which weighs two hundred and ninety pounds.

The surface of the rock wherever seen, even high above the road track is water-worn into cavities and channels descending to the southward, and great numbers of pot-holes have been uncovered, which have a tendency to a linear direction nearly north and south. In laying out the railroad, soundings were made between the two rocky barriers to the depth of near forty feet, in a peat bog, and the rock cutting was considerably diminished by laying the track about north and south, and obliterating wholly or in part many pot-holes of large and small size. Through the kindness of my friend, R. Bakewell, Esq., I refer to his drawing of the section made by the railroad on its west side.

* Figured, Geol. N. H., p. 114.

The cut is north and south about 1600 feet long, and thirty-five feet deep; the railroad is at the base, and the former carriage road at the top.

A, granite, presenting two rocky barriers *s*, *s'*, the latter somewhat the highest:—these to the eastward rise more rapidly into ridges than on the west. The course of the channels in the granite is diagonal from the east side and descends south, showing certainly the direction of the stream. (*q*) Quartz veins from one to four inches thick, dipping from 35° to 42° S.E., intersecting the granite. These are cut off in barrier (*s'*) by two large veins (*f*) (*f'*), of whitish green feldspar with mica, and in some parts is handsome graphic granite, and all much harder and more difficult to excavate than the granite;—(*f*) is fifty-six feet wide and (*f'*) twenty-one feet. Their course is N. 18° E., and dip westerly 66°, and by the light color of the feldspar, they may be traced by the eye in a tortuous course far up the hills. B B' B'' are deposits without stratification, of fine and coarse gravel with large and small rounded pebbles covering the granite and extending somewhat lower than the track of the railroad; the portion B'' was made up chiefly of pebbles of the larger size, even one foot by one and one half foot. C is a bed or deposit of swamp muck, filling to the brim the excavation in the gravel and covering it from *s* to *s'*. This extends below the track, and east and west, and is some two hundred feet wide, in the line of section between B' B''. The draining of this swamp on the south, caused it to settle and tear apart in large patches, and to prevent its filling the track as fast as the excavations went on, a close row of piles thirty feet long was driven on each side and braced apart at top. Coniferous trees of considerable size, eighteen inches diameter, are found in this at all levels, prostrate and with roots attached, and also lying on stumps that were still in a vertical position; when cut they were found in the interior quite sound and of bright color. (*t*) Is a dike of gray amygdaloidal trap, three and one half feet wide. Its course is N. 30° E.; it was traced southwesterly up to the top of the ridge some hundreds of feet above

A, Granite.—B B' B'' Gravel, pebbles and sand.—C, Peat containing trees and stumps.—*f*, *f'*, Feldspar veins.—*q*, *q*, Quartz veins.—*s*, *s'*, Summits. *t*, Trap dike.

the road, for a distance of near half a mile, where it is only one foot wide; it may also be traced some way on the eastward side of the road.

In my note-book are memoranda of pot-holes measured here, some of which (the last three) have been since in part removed.

1. 16 inches diameter and 4 feet deep.
2. 4 feet " and 4 " "
3. 3½ and 4 ft. " and 10 " "
4. 4½ feet " and 8 " "
5. 13 " " and 12 " " now less than a semicircle.
6. 5 " " and 8 " " a semicircle.
7. 8 " " and 10 " " in two curves, as if two holes had been worn into one.

No. 1, was filled with peat, and discovered by sounding with an iron bar; at a single blow the bar struck on the bottom a flattened, rounded smooth stone, of about four pounds weight, which was the last agent in the excavation of the hole. There is also a rocky channel some rods in length, oblique from the northeast, which is cut off by the railroad at its lower end; it is twelve feet wide and eleven feet deep, and contains near its mouth large rounded granite boulders from one to seven feet diameter. Such masses as these, with the great number of similar ones, large and rounded, in the portion of the gravel bed at B″, are proofs of the tumultuous action of a great body of water, by whose agency they were carried along into this whirlpool and revolved till they were rounded and often reduced to pebbles and powder, and thus removed to give place to others. At various stages in the process, some may have escaped from the excavations and were carried over the south summit (*s*), or were lodged on its north side.

The phenomena here presented, indicate a long continued discharge of a large current of water through this gap, from north to south, which has worn down the mountain range, hundreds of feet, as shown by the feldspathic veins, and especially by the *trap dike*, which was injected since the veins, as it cuts one of them. Similar circumstances must have been often repeated at higher levels, while this erosion was in progress. "The well" beside the road has been lowered three feet on one side, so as to form a channel in which the early road was made, while below this level it was perfect and eight feet deep. We may suppose, with reason, that these wells had been of similar dimensions through a long period while the action was going on, and that excavation below kept pace with the removal of the upper portion.

Between these two remarkable barriers on the north and south, the excavation in granite of this longitudinal valley is more than forty feet deep and six hundred feet wide; it has a very uneven surface, with rounded hummocks rising from the bottom, as shown on the E. and W. side of the railroad, in a section from eight

to eighteen feet high above the track. On the north side it is filled with the accumulations of gravel, and on the south side the basin in this gravel is filled with a deposit of peat, containing abundance of prostrate trees apparently of successive generations.

The configuration of the excavated gravel shows the last result of moving water; the accumulation of the swamp muck and the growth of trees in this cavity are of course of subsequent date. The violence of the current which has here acted, may be inferred from the wearing effects exhibited on the rocks of the valley, S. and E., where they are smoothed and rounded at elevations far above the stream now flowing there; also from the great depth of Tewksbury Pond, and from the extensive beds of pebbles washed clean of all fine materials, sand and soil, in Danbury, about ten miles southeast.

Again—we see no evidence at present that these excavations and irregularities were produced by water *falling from a very great height;* they are rather the effect of a uniform though violent current; the same marks are seen in the slate and hard trap of the bed of the Queechy, where pot-holes and channels and capacious excavations long and deep are abundant as the effects of a rapid stream.*

If we may safely conclude that where numerous dikes, and these it may be in groups of six or eight, are found crossing in a valley a river channel, as at Campton Falls, N. H., and reduced to a level with its bed, with occasionally one harder than the rest forming a barrier of slight elevation, we have before us a present agency which in time past, may have been sufficient for the production of the degradation indicated by the extent of the valley. So when there are large, elevated areas yet far below the peaks and ridges of the country intersected in many directions by trap dikes and the whole surface worn smooth, we hesitate not to admit that a general denuding or erosive force has acted with energy and during a long period. When we find a mountain ridge cut at right angles by one or more trap dikes, and these reduced to an even surface with the crest and sides of the mountain, and continuous across the valleys, it is not easy for the mind to forbear concluding that the valleys are valleys of erosion, although they may be narrow and some thousands of feet deep. This is illustrated by the following cases.

* In connection with these effects of larger currents, and in proof of their former existence in the channel of our present streams, I mention that a cut was made in West Hartford, Vt., on the Central Railroad, across the angle of a slate spur, about sixty feet above the White River, that opened a pot-hole to its bottom, seventeen feet deep and between three and four feet diameter. In this were found two beautifully rounded and smooth spheres of granite, one of which unfortunately was buried in the track, and the other, almost a perfect sphere, two feet four inches in diameter, and weighing over nine hundred pounds, is preserved for science at the University of Vermont at Burlington.

(*g.*) Moose Mountain is a part of a north and south range of mica and hornblende slates with quartzite. It is situated about eight miles east of Dartmouth College, and may be 1000 feet high. Between the granite knobs just east of the College and the range, there is a synclinal valley and axis, and the slates on Moose Mountain dip westerly at a high angle. In passing along the ridge some years since, I observed a depression eighteen feet wide with perpendicular sides twelve feet high, and this singular interruption of the line of the ridge led to an examination of the rock in this space. It proved to be a dike of columnar porphyritic trap running east and west, which was traceable some way down the declivity, but of a uniform surface with the sides of the mountain.

On the opposite side of the valley, and crossing it and the road obliquely and following exactly the undulating and channeled surface of the slate, is another very compact, hard, blue trap dike, with crystals of glassy feldspar, and fourteen feet wide. These dikes if produced must intersect each other, and the latter is cut down many feet by a small stream.

A few miles south where this ridge is interrupted by the valley of the Mascomey River or Enfield Pond, the precipitous bluff presents a dike some feet in width which is made up of flattened and rounded masses of trap in columns side by side, and rapidly decomposing. This is one hundred feet and more above the level of the lake, which is at the base of the ridge, and whose bed must be intersected by the dike.

(*h.*) Mount Washington, as I showed in the American Journal, xxxiv, in 1838, is covered or capped with mica slate *in place*— and as there is no evidence from diluvial scratches, boulders or rounded and smooth surfaces, of erosion or denuding forces, we infer that its peak ever has been above the reach of those agencies which have operated upon its flanks and upon the surrounding peaks.

If a fissure should occur through one of these granitic peaks from valley to valley, (it would probably be much farther extended,) and if molten lava were to fill this fissure, it could never reach the apex or remain consolidated there, unless it were supported at the *limits* of the fissure on the flanks of the mountain. It is contrary to physical laws that as the lava rose in the fissure, it should not gravitate and run into the lower places, the valleys on the sides of the mountain, and only as these were filled would it rise in the fissure, and equally in both. This must follow whether the surface be submarine or subaerial.

1. If the existing valleys were filled to the height of the peak with *diluvium* or *drift*, like the conglomerate hardpan of this region, which is so consolidated that when excavated it must be blasted, this would seem sufficient to repress or hold up the col-

umn of lava and secure a uniform dike to the full height of the peak. The hardpan would be fissured and the dike found continuous through it; but this supposition implies a *previous excavation or erosion of the valleys.*

2. If existing valleys were formerly filled with *trap* by an overflow from the fissure, they are now clear of it and have been reduced to their former condition, i. e., they have been excavated a *second time as in the former case.*

3. If the present valleys were formerly occupied by continuous rock, such as constitutes the mountains, then a support is had for the molten lava when injected to the height of the peak, so as to allow the filling of the fissure and to form a dike; and the present configuration is the result of a subsequent erosion or excavation. Whether these valleys, therefore, were ever filled with diluvium or trap, need not be shown, as we must in that case, at a previous time introduce the latter supposition, involving as it does only a single excavation.

There is a possible supposition that the valleys of the White Mountains are the result of fracture and subsidence of their areas —or of fracture and elevation of the ridges—but I know of no evidence of this, and where the rock can be traced across from side to side of a valley, the continuity is complete. To sustain the third view above, I cite the following facts.

Mount Pleasant, the third peak south of Mount Washington, is about 4500 feet high. Its top is a plain of five or six acres, so even and level that a horse may be galloped all about upon it.

It is intersected near its center by a dike of very hard, bluish trap three feet wide, whose course is east and west, which is worn off entirely smooth and level with the enclosing rock, and may be traced entirely across the top. Circumstances did not allow an examination for its continuance beyond these limits, where the sides of the mountain are covered; but by telescopic examination from Fabyan's, which showed distinctly the little column of trap fragments piled upon the dike of two feet in height, I was led to infer a probable relation between the dike and the slides on the west side of Mount Pleasant, which seemed to be in the range with it. However this may be, the dike must be considered for the reasons already given, as of much greater length than the crest of the mountain and of course extending down into or across the valleys.

Though the positive evidence may be wanting of this latter point, yet from a party of our students who, in the autumn of 1848, descended into the valley on the east side of Mount Pleasant, from directly opposite the "Lake of the Clouds," and followed the mountain stream throughout its course of falls and rapids, &c., to the valley of Dry river, and down this to its junction with the Saco in the Notch, two or three miles below the

Willey House, and some twelve miles from where they began the descent—I learn that "two or three miles above the mouth of Dry river there are several remarkable trap dikes at right angles to, and crossing the stream, and running up into the mountain on the sides; one of them is five or six feet wide and is smooth and even with the rock enclosing it, and the stream makes a nearly perpendicular plunge at this point, of eight or ten feet,"—thus presenting such phenomena as are common in other similar places, and as ought to be found constantly existing or repeated in a process of excavating a valley by a running stream.

The facts which I have recorded, showing the relations between trap dikes, which have been denuded and eroded to considerable depths by running streams, will need no comment or illustration.

In regard, however, to such cases as Mount Pleasant and Moose Mountain, where no running water is found, we must recur to the periods when the relations of land and water were very different from the present.

We are too much disposed to look upon the great features of this group of mountains as fixed so long ago as to have no connection with the minor ones now presented, and which are in process of increase. The agencies of decomposition are now at work on a scale of sufficient magnitude to produce great changes in a generation, and the accumulation of debris since August, 1826, at the gorge back of the Willey House, and in the outlets of the two below it, if we could add also the large amount of fine materials carried down stream by the Saco from these sources, are well calculated to prevent our underestimating their importance.

The gorge ½ a mile below the Willey House being in the line of some trap dikes cutting the mountain, is already a very considerable depression, and in imagination we may anticipate the time when it has become a separating valley two or three thousand feet deep, like the one east of Mount Pleasant. We have only to extend this view to the thousands of precipitous torrents, and the more advanced channels, to provide for the future intersection of these ranges, and, as the valleys are deepened and widened, for their more rapid destruction by undermining and slides. It is not my object to exclude by any means the general operation of any or all of the authentic agencies, whether marine or freshwater or others subordinate, that by future observation may be shown to have left their impress on this region—but while observation shows a very considerable erosion of these valleys and mountains now going on, I wish to present other facts which lead to the conclusion, that these *deepest valleys are but valleys of erosion.*

The examination of the valleys of the state of New York, as at the Little Falls, &c., and of its lakes in different parts, shows a difference of level and a depth of erosion of 1200 feet to 2000 feet. So also the observations on the sandstone of the Connecticut valley in Massachusetts and Connecticut, indicate its erosion to the extent of 1200 feet. This erosion of the sandstone is only consistent with a similar one in the northern portions of New England, and requires its occurrence if we would provide the constituents of the sandstone in the first place and its continuance and increase subsequently. Whether this result is referable to one period or another is not now a question.

The following facts are cited from the Report of the Geology of New Hampshire, to sustain the general proposition, and which is also strengthened by the evidence afforded by metallic veins in positions similar to that of the trap.

1. The Lower Patuccoway Mountain of syenite in Nottingham is cut, through its summit, into two nearly equal parts by a dike of columnar greenstone trap from six to twelve inches wide, and which can be traced for a quarter of a mile till concealed by the soil. This mountain is 780 feet high above the sea.

2. In Piermont the mica slate is intersected by numerous dikes of greenstone trap; and from Piermont to Haverhill Corner, nine dikes are found, some of them porphyritic, and one so filled with magnetic iron pyrites as to affect the compass.

3. Red Hill, of syenite, and 2000 feet above the level of the sea, is crossed at about one-third its height by a large dike of porphyritic trap, N. 30° W.

4. On the declivity of the westerly peak of Gunstock Mountain, which is 1561 feet above lake Winipissiogee, is a vein of magnetic oxyd of iron, the pieces of which have polarity, and large dikes of trap occur on the southerly peak.

5. Baldface Mountain, in Jackson, of granite, is cut through its midst by a few trap dikes, and at a height of 1404 feet above its base, and in other places is cut by veins of peroxyd of iron of great width, which are traced down its flanks.

6. Several trap dikes in Jackson contain carbonate of lime, and cut through mica slate, granite and a granite vein, one of which is fifty feet wide.

7. At Hampton Falls, and on to the sea, the hard flinty rock is cut by dikes of trap.

8. In Eaton, dikes of porphyritic trap from ten to sixteen feet wide cut through a hill of granite, and again in another place a trap dike four feet wide cuts a hill of granite.

9. On the east flank of the White Mountains, on the Pinkham road in Jackson, the mountain ledge of mica and chiastolite slate

1. p. 50.—2. p. 65.—3. p. 71.—4. p. 72.—5. pp. 78, 79.—6. p. 80.—7. p. 93.—8. pp. 95, 98.—9. p. 99.

is cut by two large trap dikes, and Town's hill in Lancaster, is intersected by trap dikes in limestone.

10. Trap dikes, porphyritic and dark brown compact, occur at Berlin Falls, and are also found in passing from Berlin to Lancaster.

11. In Littleton are trap dikes cutting mica slate.

12. Thorn Mountain, in Jackson, consisting of a porphyry, is cut through at top by veins of magnetic oxyd of iron descending its flanks, and by a dike of basalt.

These examples of trap are at very various heights above the sea, and are a fair illustration of the amount of erosion of the rocks in their several localities. I know of no more valid objection to the conclusions based on the evidence afforded by the relations of the trap in New Hampshire, than would lie against those derived from the trap in other formations, whether in the mountains of northern New York or in the coal formation, or in the sandstones of all countries; and future examination in the very instructive geological field of the White Mountains will doubtless furnish much more similar evidence.

ART. XIX.—*Contributions to the Mycology of North America;* by Rev. M. J. BERKELEY, of England, and Rev. M. A. CURTIS, of South Carolina.

61. AGARICUS ANTILLARUM, Fries.—In fimetis. May–Nov. Society Hill, S. Carolina.

62. COPRINUS TERGIVERSANS, Fr.—Ad terram. Dec. Santee Canal, S. C. Mr. Ravenel.

63. PAXILLUS POROSUS, Berk.! in Lea's Catalogue.—Ohio! Mr. Lea. S. Car.! In sylvis humidis. Aug.–Oct.

64. HYGROPHORUS MUCILAGINOSUS, Berk. and Curt.;—pileo valde mucilaginoso lætecolori convexo demum plano striato; stipite fragili subconcolori fistuloso; lamellis decurrentibus crassis carneis. In paludosis. July. Society Hill.

Cap 6–9 lines broad, of a bright pale reddish yellow, darker in the centre. Stem ½ inch high, a line or more thick, composed of longitudinal fibres, subpellucid, pale yellow or carneous. Gills distant, unequal, fleshy. Allied to *H. Cantharellus*, Fr., from which it is readily distinguished by its very mucilaginous pileus and thick gills; and from *H. lætus*, Fr., by its brittle stem.

65. H. LURIDUS, Berk. and Curt.;—pileo campanulato umbonato pallide fusco viscosissimo; margine striato crenato; stipite

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10. p. 104.—11. p. 109.—12. p. 145.

fistuloso concolori; lamellis crassis venoso-connexis adnexis albis. In paludosis. July. Society Hill.

Cap 7–9 lines broad, pale brown, darker in the centre. Stipe 1½ in. long, about a line in thickness, composed of longitudinal fibres. Gills ventricose, shortly adnate. Not very closely allied to any species described, except perhaps to *H. unguinosus*, which is however more robust and of different habit.

66. H. COCCINELLUS, Fr.—In terra arenosa humida. Aug. Society Hill.

67. H. CHLOROPHANUS, Fr.—Ad terram inter folia. June. Hillsborough, N. Car.

68. LACTARIUS INSULSUS, Fr.—Ad terram in sylvis. Aestate. Hillsborough, N. C.

Agaricus fuliginosus, *vellereus*, and *camphoratus*, enumerated in a previous paper, belong to this genus.

69. CANTHARELLUS UMBONATUS, Fr.—In sylvis. Oct. R. Island. Mr. Olney.

70. MARASMIUS OPACUS, Berk. and Curt.;—gracilis; pileo convexo ruguloso opaco pulverulento albido; stipite insititio elongato pulverulento-subfurfuraceo pallido; lamellis ventricosis distantibus adnexis. Ad ramulos et folia dejecta in sylvis. Aestate. Society Hill and Santee Canal, S. Car.

Cap about 2 lines broad, sometimes slightly depressed around a central umbo, dirty-white, scarcely striate or sulcate. Stem 1–1½ inch. high, ⅓ of a line thick, of the same color with the cap, furfuraceous toward the base. Gills moderately broad, slightly adnate, with the interstices nearly even. Nearly allied to *M. ramealis*, but, like *M. synodicus*, is far more elongated. From the latter it differs in its rather broad, not vein-like gills; and from *M. candidus*, in its opake pileus.

71. M. PITHYOPHILUS, Berk. and Curt.;—pileo e convexo plano-umbilicato sulcato-striato brunneolo; stipite insititio solido concolore pulverulento-furfuraceo; lamellis fusco-carneis subdecurrentibus. Ad folia Pinea dejecta. July. Society Hill.

Cap 4 lines broad, impressed-striate, dry, submembranaceous, whitish-brown. Stipe ½ in. long, scarcely ½ line thick, firm, subequal, pale or brownish pulverulent, clothed toward the base with minute furfuraceous scales. Gills unequal, forked, undulated. Agrees in habit with *M. fœtens*, but the stem is more opake, and the gills are by no means annulato-adnexed.

72. M. SPONGIOSUS, Berk. and Curt.;—pileo plano albido-fusco; stipite pulverulento basi incrassato spongioso fulvo-villoso; lamellis albidis subconfertis. Inter folia putrescentia in humidis. June, July. Hillsborough, N. C. and Society Hill, S. C.

Cap 4–6 lines broad, darker in the centre, obtuse. Stem 1½ in. long, brown, often much twisted, thickened toward the base

and clothed with a tawny villus. Has much the aspect of *M. plancus*.

73. M. SIMILIS, Berk. and Curt.;—pileo membranaceo plicato opaco albido; stipite gracili elongato nitido fusco; lamellis paucis latis adnexis venoso-connexis albidis. Ad terram. July, Aug. Society Hill.

Gregarious. Cap 2–3 lines broad, dull white, smooth, covered with minute wrinkles. Stem 2 in. long, very slender, hardly pulverulent. Gills ventricose. Allied to *M. hæmatocephalus*, Fr., from which it is easily distinguished, at least by color.

M. hæmatocephalus, (No. 2 of these Contributions,) I find also at Society Hill, S. C.; sometimes having a stem 3 in. long with a cap 12–15 lines broad. Mr. Olney has also sent it from Rhode Island.

74. M. GRAMINUM, Berk.!—Ad folia graminum, herbas, etc. in hortis. June. Society Hill.

75. M. VAILLANTII, Fr.—Ad cortices emortuos, e. g. Vitis. Aug. N. and S. Car.

76. M. PLANCUS, Fr.—In sylvis acerosis. R. Island; Mr. Olney.

77. LENTINUS RAVENELII, Berk. and Curt.;—pileo umbilicato submembranaceo striato squamuloso maculato; stipite curto tenui furfuraceo-squamoso; lamellis tenuibus subdistantibus dente-decurrentibus venoso-connexis. Ad lignum putridum in humidis. April. Santee Canal, S. C. Mr. Ravenel.

Scattered. Cap 1–1½ in. broad, plano-convex, white, clothed with minute rufous velvety scales which are crowded and confluent in the centre. Stem 1 in. long, 1 line thick, solid, white, with rufous scales. Gills white, slightly erose. A very pretty species allied to *L. tigrinus*, but much more delicate. The pileus is thin, and in consequence when dry it has an hygrophanous aspect.

78. L. CESPITOSUS, Berk.! in Lea's Catalogue.—Very abundant in N. and S. Car: from July to Nov.; at the base of stumps and on buried roots. When dry it has a kind of acid-sweetish odor not unlike that about a cider-press.

79. PANUS DORSALIS, Fr.—Ad lignum mortuum Pini [et Liquidambaris?] Autumno, Hieme. N. and S. Car.

80. XEROTUS DEGENER. Fr.—Ad terram argillaceam inter muscos. June. Hillsborough, N. C.

81. LENZITES UNGULÆFORMIS, Berk. and Curt.;—albida lignea subtriquetra inæquabilis glabrata nitida; lamellis ligneis latis poroso-ramosis.—Ad lignum aridum. Wilmington, N. Car.

Cap 2 in. broad, 1¼ in. long, ¾ thick, rather elongated, villous when young but becoming smooth and shining; surface unequal,

once or twice sulcate, with some trace of almost obliterated villosity towards the margin. Gills broad, thin but woody, branched, and here and there forming sinuous pores.—Allied to *L. betulina*, but more rigid. It also resembles *L. aspera*, but has not the scabrous surface of that species, nor has it the same habit.

82. L. TRICOLOR, Fr.—Ad ramos dejectos in sylvis humidis.—N. and S. C. Item, R. Island. Mr. Metcalf.

83. L. KLOTSCHII, Berk.!—Ad truncos dejectos. Oct.–March. N. and S. Car. Item, R. Island. Mr. Bennett.

84. L. STRIATA, Fr.—Ad lignum aridum. Society Hill and Santee Canal, S. Car.

85. L. CORRUGATA, Fr.—Ad ramos Castaneæ. R. Island. Mr. Metcalf; Mr. Bennett.

86. BOLETUS ELEGANS, Schum.—Ad terram. Aestate. Hillsborough, N. C.

87. B. VERSIPELLIS, Fr.—Ad terram. Aug. Hillsborough, N. C.

88. B. RUBIGINOSUS, Retz.—Ad terram in sylvis. Sept. Hillsborough. N. C.

89. POLYPORUS ARCULARIUS, Fr.—Ad ramos dejectos in humidis. May. Raleigh, N. C.

90. P. BOUCHEANUS, Fr.—Ad ligna. July, Aug. Hillsborough, N. C. Item, Ohio! Mr. Lea; and Penn Yan, N. Y.! Dr. Sartwell.

91. P. CURTISII, Berk.;—pileo excentrico molli-suberoso sulcato zonato ochroleuco hic illic sanguineo-laccato; stipite elongato rugoso sanguineo-laccato; hymenio ex albo ochraceo; poris punctiformibus.—Ad basin truncorum. N. and S. Car.

Cap 3–5 in. broad, convex, more or less grooved and zoned, of a rather soft corky texture, covered with an ochraceous often opake laccate crust which in parts is sometimes sanguineous. Substance toward the tubes cinnamon, above ochraceous, not zoned, traversed with laccate lines parallel to the surface. Margin obtuse. Stipe 2–5 in. long, ½–1 in. thick, uneven, shining. Hymenium white becoming ochraceous and brownish-cinnamon, sometimes partly laccate. Pores not angular, cinnamon colored, stratose within.—This fine species is closely allied to *P. lucidus*, but differs as above. It has also some resemblance to *P. ochreolaccatus*. Mont.

92. P. ELEGANS, Fr.—Ad terram. Aug. R. Island. Messrs. Metcalf and Bennett.

93. P. PES-CAPRÆ, Pers.—Ad terram in montosis. Hillsborough, N. C.

94. P. LOBATUS, Fr.—Ad lignum in terra. Hillsborough, N. C. Item, Santee Canal! S. C. et in Georgia! Mr. Ravenel.—Habet odorem fortem farinæ recentis.

95. P. (Anodermei) CAROLINIENSIS, Berk. and Curt.;—pileo molli-suberoso reflexo postice effuso inæquabili ochraceo-albido subsericeo strigis innatis asperulo subzonato; poris mediis dentatis acie plus minus lacerata.—Ad truncos emortuos Quercus [et Liriodendri?] Autumno, Hieme. S. Car.

Pileus 2–5 in. broad, ½–2 in. long, much effused behind, sometimes nearly resupinate, of a soft corky texture, rugose, slightly silky with innate or raised strigæ which sometimes project from the surface, sometimes nearly smooth with innate fibrillæ; margin acute. Pores of the same color with the cap, middle sized, $\frac{1}{3}\frac{1}{6}$ of an inch broad, dissepiments thin and often broken up; sometimes the edge of the pores is obtuse.—Resembling *P. borealis*, Fr., and *P. Symphyton*, Schwein., of a looser texture than either, and with larger pores than the former.

96. P. (Placodermei) PALUSTRIS, Berk. and Curt.;—pileo carnoso-suberoso dimidiato obtusissimo cute tenui rivulosa nitidiuscula vestito; poris niveis non stratosis minutis angulatis.—Ad Pinum palustrem. Santee Canal. Ravenel.

Pileus 2 in. broad, 1 long, ½ thick, subungulate, clothed with a thin rather shining cracked ochraceous cuticle. Substance white uniform. Pores about two lines long, minute, white within and without, not at all stratose, slightly angular, with thin dissepiments and rather irregular edge.—Nearly allied to *P. officinalis*, but the pores are smaller, pure white, and not at all stratose; nor is the flesh bitter when dry or easily reduced to powder.

97. P. SALICINUS, Fr.—Ad truncos putridos. Santee Canal. Ravenel.

98. P. CARNEUS, Nees.—Ad palos. June. Society Hill.

99. P. (Placodermei) CUPULÆFORMIS, Berk. and Curt.;—pileo pezizæformi e vertice elongato stipitato albido cinnamomeo puberulo; hymenio plano-excavato cinnamomeo; poris minutis. —Ad corticem Rhois copallinæ; S. Car. Castaneæ; R. Island! Mr. Olney. Vere.

Gregarious. Cap 1–1½ line broad, attached by the vertex which is elongated into a short stem, cinnamon clouded with grey, slightly downy. Hymenium sunk below the swollen margin. Pores very minute.—Allied to *P. pullus*. Mont. and Berk.

100. P. (Inodermei) XALAPENSIS, Berk.;—pileo flabelliformi membranaceo zonato sericeo glabrescente; poris parvis dissepimentis tenuibus membranaceis hydnoideo-laceratis.—Ad ramos dejectos cariosos. Oct. Society Hill.

Cap thin, variously lobed, 2–4 in. long, pale, silky, at length nearly smooth and shining, repeatedly but delicately zoned. Hymenium white; dissepiments becoming soon torn and toothed so as to give the appearance of a Hydnum.—Closely allied to *P. elongatus*, Berk.—This species was first discovered in Xalapa by Mr. Harris.

ART. XX.—*Connection between the Atomic weights and the physical and chemical properties of Barium, Strontium, Calcium and Magnesium, and some of their Compounds;* by E. N. HORSFORD, Rumford Professor in the University at Cambridge.

Read before the Cambridge Scientific Association.*

THE great discovery of isomorphism by Mitscherlich,† and the affiliated one by Kopp,‡ of the identity of the specific volumes of isomorphous bodies are among the brilliant points in the progress of the chemistry of this century.

The latter seems to have had its origin in a conviction that in the atomic weight of a body—all its attributes have what may be denominated a *product expression*. The factors are *form*, *volume* and *density*. Each may vary, and with it the atomic weight will vary; for example:—the volume and form being constant, increase of density will be accompanied by increase of atomic weight: or form being constant, increase of density will be accompanied by increase of atomic weight, or, density and volume being constant, modification of form will influence the atomic weight.

The object of the following paper is to show that the properties of the metals, barium, strontium, calcium and magnesium, and of their compounds generally, are, in their intensity, in the order of their atomic weights. It will be seen that the law is more true of the first three than of these taken in connection with the fourth.§

The signification of the term intensity, as used above, may be thus illustrated. Sulphate of baryta requires 43000 parts of water for its solution. Sulphate of strontia 15029 parts at 11° C.‖ Sulphate of lime ($CaO, SO_3, 2HO$) in 380 parts of cold water, and 388 parts of hot water,¶ and sulphate of magnesia with seven atoms of water, 0·799 parts at 18·75°.**

	Solubility.	At. W.
BaO, SO_3 . . .	43000·00	116·5
SrO, SO_3 . . .	15029·00	91·7
CaO, SO_3 . . .	460·00	68·
MgO, SO_3 . . .	0·79	60·7

* A summary of some of the conclusions arrived at by the author were communicated to the American Association of Geologists and Naturalists, at their meeting in Boston in 1849.

† Ann. Chim. Phys., xiv, 172; xix, 350; xxiv, 264, 265. Pogg. Ann., xii, 137; xxv, 300; xlix, 401.

‡ Pogg. Ann., xlvii, 132; lii, 243–262. Ann. Chem. u. Phar., xxxvi, 1.

§ It is to be regretted that so little is known of the properties of the compounds of magnesia. Their eminent solubility in water, and the difficulty with which any of the salts of this base may be made to crystallize, have made this field of investigation less inviting than many others.

‖ Brandes u. Silber, Br. Arch., xxxiii, 61.

¶ Giese. According to Bucholz, 480 parts cold or hot.

** Gay Lussac. The anhydrous sulphate is soluble at 0° C. in 3·885 parts of water.

Here *intensity* is the same as *degree of solubility.* In other words, the solubilities of the above salts are in the order of their atomic weights.

The truth of the general proposition will be apparent from considering the following facts.

I. Barium unites with two atoms of oxygen, and is stable in this state of combination at ordinary temperatures.*

Strontium and calcium peroxyds are only known in combination with water.†

Magnesium combined with two atoms of oxygen is unknown.

II. Barium, strontium and calcium all oxydate at ordinary temperatures in the air.

Magnesium does not.

III. Barium thrown into water causes decomposition with a stormy evolution of hydrogen gas.

Strontium and calcium are both dissolved with escape of hydrogen.

Magnesium may be washed in water that has been thoroughly freed from air by boiling, without diminution of its lustre.

IV. Baryta moistened with water enters into combination with it, attended by such evolution of heat as melts the hydrate formed.‡

Strontia falls with water to a white pulverulent hydrate, with the production of intense heat. Lime similarly treated yields a heat that will fire sulphur.§

Magnesia in uniting with water is but slightly heated.‖

V. Hydrate of baryta loses none of its water under intense red heat.¶

Hydrate of strontia, by long continued red heat, melts, and by higher heat loses all its water.**

Hydrate of lime, by moderate red heat without melting, loses its water.

Hydrate of magnesia loses its water below the red heat.

VI. Carbonate of baryta, an hour and a half exposed to the most effective blast furnace heat, loses its carbonic acid.††

Carbonate of strontia, loses its carbonic acid in the strong heat of an open fire.‡‡

Carbonate of lime is decomposed at a red heat.

Carbonate of magnesia loses its carbonic acid at a moderate red heat.

VII. Selenite of baryta and selenite of strontia are insoluble in water.

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* Thenard. Ann. Chem. Phys., viii, 308. Rammelsberg, Pogg., xliv, 558.
† Thenard. Ann. Chem. Phys., viii, 313. ‡ Döbereiner. Schw., vi, 367.
§ Ann. Chem. Phys., xxiii, 217. ‖ H. Davy.
¶ Bucholz u. Gehlen, iv, 258.
** Denham Smith. Phil. Mag., ix, 87. Pogg., xxxix, 196.
†† Abich, Pogg., xiii, 314. ‡‡ Ibid, 315.

Selenite of lime and selenite of magnesia are slightly soluble in water.

VIII. Biselenite of baryta dissolves with difficulty in water.

The same is true of the corresponding salts of strontia and lime.

Biselenite of magnesia is a doughy deliquescent uncrystallizable salt.

IX. Selenate of baryta is as little soluble as the sulphate.*

Selenate of magnesia is equal in solubility to the sulphate.†

X. Iodid of barium crystallized with an atom of water, is readily soluble in water, but does not deliquesce upon exposure to the air.‡ It is deliquescent.§ It is not fusible.

Iodid of strontium is readily soluble in water.‖ It is fusible below red heat.

Hydrated iodid of calcium may be crystallized. It deliquesces on exposure to the air,¶ and fuses below red heat.

Hydrated iodid of magnesium crystallizes with difficulty, and deliquesces readily.

All decompose, when heated by access of air, into metallic oxyds.

XI. Iodate of baryta with one atom of water is soluble in 1746 parts of water at 15° C. and in 600 of boiling water.**

Iodate of strontia with six atoms of water is soluble in 342 parts of water at 15° and in 110 of boiling water.††

Iodate of lime with five atoms of water dissolves in 253 parts of water at 15° C. and in one hundred and ten parts of boiling water.‡‡

Iodate of magnesia is soluble in water, but has not been further examined.

XII. Bromid of barium with two atoms of water is unaffected by exposure to air.

Bromid of strontium with six atoms of water loses its water at a feeble heat.§§

Anhydrous bromid of calcium deliquesces rapidly in the air. That with one atom of water crystallizes with difficulty from the solution of bromid of calcium.

XIII. Bromates of baryta, strontia, lime and magnesia crystallize with water, the first three with a single atom.

Bromate of baryta loses its atom of water not below 200° C.

Bromate of strontia by 120° C., bromate of lime by 180° C. and bromate of magnesia at ordinary temperatures.

XIV. Bromate of baryta dissolves in 130 parts of cold water.

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* Berz. Pogg., xxxii, 11. † Berz. Schw., xxiii, 454.
‡ Gay Lussac. § O. Henry. ‖ Gay Lussac.
¶ Berthemot. J. Pharm., xiii, 416.
** Rammelsberg. †† Ibid. ‡‡ Ibid. §§ Löwig.

Bromate of strontia in three parts; bromate of lime in 1·1 parts, and bromate of magnesia in 1·4 parts.*

XV. When chlorid of barium is formed by leading the vapor of hydrochloric acid over heated baryta, the decomposition is attended with the evolution of heat and a red light. The same phenomena occur in the similar production of chlorid of strontium.

That of chlorid of calcium is attended with heat only.

Chlorid of magnesium cannot be formed in this manner.

XVI. The specific gravity of anhydrous chlorid of barium is 3·7037, of chlorid of strontium 2·8033, of chlorid of calcium 2·0401.†

XVII. When heated in dry air, chlorids of barium, strontium and calcium become alkaline; while chlorid of magnesium remains unchanged.

XVIII. Crystallized chlorids of barium and strontium do not change upon exposure to the air.

The chlorids of calcium and magnesium deliquesce rapidly upon exposure to the air.

XIX. Chlorid of barium is soluble in from 8108–6885 parts of cold alcohol, of 99·3 per ct., and in 4875 parts of boiling alcohol.

Chlorid of strontium is soluble in from 116·4–111·6 parts of cold and in 262 parts of boiling alcohol of 99·3 per ct.‡

XX. Chlorate of baryta requires four parts of water for its solution.

Chlorates of strontia, lime and magnesia deliquesce in the air.

XXI. Chlorate of baryta is insoluble in alcohol.

Chlorates of strontia, lime and magnesia are soluble in alcohol.

XXII. Fluorid of barium is readily soluble in hydrochloric and nitric acids.

Fluorid of calcium is slightly soluble in boiling acids, and fluorid of magnesium scarcely at all in cold or hot acids.

XXIII. Fluorid of barium is soluble in aqueous hydrofluoric acid; fluorid of strontium less; fluorid of calcium a mere trace, and fluorid of magnesium not at all.

XXIV. Nitrites of baryta and strontia do not change in air.

Nitrites of lime and magnesia deliquesce upon exposure to the air.§

XXV. Nitrate of baryta requires 20 parts of water at 0° for solution. Nitrate of strontia 5 parts of cold water. Nitrates of lime and magnesia deliquesce most rapidly in the air.

XXVI. Nitrates of baryta and strontia are not soluble in alcohol. Nitrates of lime and magnesia are soluble.

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* Rammelsberg. Pogg. Ann., lii, 81.
† Karsten.
‡ Fresenius. Liebig's Ann., Bd. lix. 117–128.
§ Mitscherlich.

XXVII. Carbonate of baryta is soluble in 14137 parts of cold, in 15421 of boiling water. Carbonate of strontia in 18045 parts cold water. Carbonate of lime in 10601 of cold and 8834 of boiling water.*

XXVIII. Oxalate of baryta with one atom of water is soluble in 200 parts of cold or boiling water.†

Oxalate of strontia with one atom of water is insoluble in water‡—even in boiling water.§

Oxalate of magnesia with two atoms of water only very slightly soluble in water.‖

XXIX. Formiate of baryta is soluble in 4 parts of cold water.¶

Formiate of lime in 8 parts of cold and in 10 parts at 19° C.**

Formiate of magnesia is soluble in 13 parts of cold water.††

XXX. Sulphovinate of baryta is soluble in 0·92 parts of water at 17° C.‡‡

Sulphovinate of lime is soluble in 0·8 parts of water at 17° C.§§

XXXI. Acid urate of baryta is insoluble in water. That of strontia somewhat soluble in hot water. That of lime of difficult solubility. That of magnesia, is soluble in 3500–4000 parts of cold and 150–170 parts of boiling water.‖‖

XXXII. Neutral alloxanate of baryta is less soluble than the corresponding salts of lime and magnesia.

XXXIII. The above salts of lime and magnesia are somewhat soluble in alcohol. The salt of baryta is not.¶¶

XXXIV. Ferrocyanid of barium ($Ba_2Fe\ Cy_3$) dissolves in 584 parts cold,*** 1800,††† and in 116 parts of boiling water.‡‡‡

Ferrocyanid of strontium dissolves in 2 parts of cold and 1 of boiling water.§§§

Ferrocyanid of calcium deliquesces in the air.‖‖‖

Ferrocyanid of magnesium with 12 atoms of water dissolves in 3 parts of water.¶¶¶

It is to be regretted that other properties, including specific gravity, specific heat and light-refracting and heat-conducting power have been so little studied. Still, enough of correspondence and gradation among the properties of the compounds of this group has been shown to establish the general proposition that the intensities of their chemical attributes are in the order of the atomic weights of the metals, and lead to the conviction that other attributes might be found to be in similar gradation of intensity.

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* Fresenius. Liebig's Ann., Bd. lix. s. 117–128.
† Bucholz. Taschenbuch, 18. 18. ‡ Scheele. § Wackenroder.
‖ Graham. ¶ Arvidson. ** Gobel. †† Arvidson. ‡‡ Magnus.
§§ Marchand. ‖‖ Bensch. Liebig's Ann., liv, 189–208.
¶¶ Schlieper, Liebig's Ann., Bd. lv, s. 272-279. *** Duflos. ††† Porret.
‡‡‡ Duflos. §§§ Bette. Ann. Pharm., xxviii, s. 54. ‖‖‖ Ittner.
¶¶¶ Bette. Ann. Pharm., xxii, s. 152; xxiii, s. 115.

The resistance to the passage of an electric current through the fluid solutions of these bodies might, it was conceived, be in the order of their atomic weights.

To ascertain if this supposition were founded, an apparatus was employed an account of which has been published in my paper upon the resistance of fluids to electric conduction,* and may be referred to here, as a perusal of this description will be necessary in order to the appreciation of the application of the law.

The fluids employed were nitrates, hydrochlorates and acetates of baryta, strontia, lime and magnesia.

The baryta and strontia salts were prepared from the sulphids (derived from the native sulphates by reduction with charcoal and rye meal); the lime salts from the hydrate, and the magnesia salts from magnesia alba.

The barium and strontium sulphids were dissolved in the several acids with slight excess of acid filtered, neutralized by addition of hydrates of baryta and strontia to the respective solutions, concentrated by evaporation, crystallized, and the crystals washed and dissolved.

The hydrate of lime was dissolved in the several acids, the solutions kept alkaline by excess of lime to precipitate the iron, filtered, and accurately neutralized.

The magnesia alba, with the aid of heat, was dissolved in the several acids and carefully neutralized.

A saturated solution of chlorid of barium, the least soluble of the salts employed, at 16° C., had a specific gravity of 1·042. The solutions of the other chlorids and remaining salts were with great care brought to the same degree of dilution. Two series of results were obtained with the solutions of chlorid of barium and chlorid of strontium. The series in column I. were with solutions of the specific gravity above mentioned. The series in column II. with these solutions diluted with equal measures of distilled water, presenting in an equal length and breadth of liquid, twice the depth. It will be seen that the resistance was very nearly the same.

The solutions of 1·042 specific gravity were then successively placed within the galvanic circuit, and a constant length, breadth and depth of the liquid maintained, and the obstruction they presented to the electric current replaced by windings of German silver wire. The windings correspond to and express the resistance the liquids severally presented.

Table I. presents the results obtained under the following conditions.

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* Pogg. Ann., Bd. lxx, s. 238, and Amer. J. Sci., vol. v, ii ser., 1848, 343.

Specific gravity of liquid, . . . 1·042
Cross section of liquid, . . . 0·00172 M.
Length of layer, ... 0·4 M.
Strength of battery, 5 Bunsen's pairs.

The exceptions in relation to the results under II. and III. have already been alluded to.

Column A contains the number of experiments; column B, the degrees of deflection of the magnetic needle as indicated by the galvanometer; column C, the windings and decimal fractions of windings of German silver wire, as indicated by Wheatstone's Regulator.

Table I.

		BaO, HCl I.		BaO, HCl II.		SrO, HCl I		SrO, HCl II.			CaO, HCl		MgO, HCl
A	B	C	B	C	B	C	B	C	B		C	B	C
1	14°	37·42	14°	36·04	14°	24·07	15°	28·68	16°	13′	22·98	16° 15′	23·18
2	11	39·60	12	38·10	13	27·91	12	27·04	15		22·90	19	21·87
3	12	35·50	..	....	15	26·62	12	26·78	15	30	22·95	16	22·80
4	13	34·00	..	....	13	26·88	..	....	15	30	23·84	14	23·71
5		....	..	....	12	27·34	..	....	14		21·75	....	22·89
Average,		36·63	..	37·07	..	26·56	..	27·50	....		22·88	....	22·89

The subsequent experiments were made with the platinum diaphragms ·25 M asunder, the specific gravity 1·042 and the remaining conditions the same as in the experiments above recorded.

It will be observed that the resistance is pretty nearly in the ratio of the diminished length of the layer of liquid in the case of the hydrochlorates. The want of precise correspondence was ascribed to the presence of chlorine upon the platinum plates producing the effect of so-called polarization. The odor of chlorine was remarked in the experiments with the hydrochlorates.

Table II.

No. of experiment.	Deflection of needle.	BaO, HCl Windings of German silver wire.	Deflection of needle.	SrO, HCl Windings of German silver wire.	Deflection of needle.	CaO, HCl Windings of German silver wire.	Deflection of needle.	MgO, HCl Windings of German silver wire.
1	13°	20·36	12°	17·09	16°	15·12	18°	14·90
2	"	20·73	14	17·38	"	15·19	"	14·60
3	"	21·93	14 ·30′	17·36	"	15·15	"	14·92
4	"	20·45	"	17·81	"	14·70	"	14·72
5	"	20·98	14	17·97	"	15·10	"	14·45
6	"	21·75	"	17·89	"	15·30	"	14·49
7	"	20·75	"	17·65	"	14·54	"	14·99
8	"	20·28	"	17·70	"	15·03	"	13·90
9	"	20·04	"	16·93	"		"	14·05
10	"	20·18	"	17·00	"		"	14·14
11	"	20·94	"	17·03	"		"	14·94
12							"	14·38
Average		20·76		17·34		15·01		14·54

TABLE III.

No. of experiment.		BaO, NO_5		SrO, NO_5		CaO, NO_5		MgO, NO_5
	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	14°	31·25	14°	29·31	17°	20·29	16°	17·66
2	"	31·15	"	29·47	16	21·41	"	17·97
3	"	30·25	"	29·26	"	20·47	"	17·90
4	"	31·78	"	28·90	"	21·10	"	17·34
5	"	30·00	"	29·10	15	21·39	"	17·99
6	"	31·20	"	28·76	"	20·81	"	17·72
7	"	30·23	"	28·50	"	20·02	"	17·28
8	"	30·07	"	28·12	"	21·57	"	17·85
9	"	30·37	"	29·22	"	20·45	"	17·01
10	"	30·00	"	28·40	"	20·20	"	17·90
11	"	30·08	"		"	20·10	"	17·21
					"	20·00	"	17·62
					"	20·01	"	17·57
					"	20·15		
					"	20·58		
Average		30·58		28·90		20·57		17·62

TABLE IV.

No. of experiment.		*$BaO, \bar{A}$		$SrO, \bar{A}$		$CaO, \bar{A}$		$MgO, \bar{A}$
	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	9°·30′	34·48	12°	36·33	12°·30′	36·42	12°	35·26
2	"	34·02	"	36·00	11	36·12	"	34·60
3	"	34·00	12 ·30′	36·97	9 ·30	36·62	"	35·08
4	"	34·50	"	36·00	9	35·00	"	35·29
5	"	34.90	"	36·55	8 ·30	35·31	"	35·69
6	"	34·26	"	37·39	"	35·00	"	35·45
7			"	36·13	"	35·25	"	35·04
8			"	37·25	"	35·39	"	35·09
9			"	36·27	"	35·60		
10			"	37·02				
11			"	37·00				
12			"	36·03				
13			"	36·04				
14			"	37·15				
Average		†42·95		36·50		35·63		35·18

SUMMARY OF RESULTS.

I.

Salts.	Atomic weights.	Results. I.	II.	III.
BaO, HCl, .	152·0	36·63	37·07	20·76
SrO, HCl, .	88·3	26·56	27·50	17·34
CaO, HCl, .	64·5	22·88	. .	15·01
MgO, HCl, .	56·7	22·89	. .	14·54

II.

BaO, NO_5, . . .	130·5	30·58
SrO, NO_5, . . .	105·8	28·90
CaO, NO_5, . . .	82·0	20·57
MgO, NO_5, . . .	74·2	17·62

* Length of liquid section ·20 M.

† ·20 gave 34·36, ·25 would give 42·95.

III.

$BaO, \bar{A}$, ...	127·5	42·95
$SrO, \bar{A}$, ...	102·8	36·50
$CaO, \bar{A}$, ...	79·0	35·63
$MgO, \bar{A}$, ...	71·2	35·18

The above results led to the conviction that all the attributes of these metallic bases and their compounds would probably be found intense in the order of their atomic weights, a conviction which I expressed after presenting a summary of the foregoing results, to the meeting of the American Association in 1847.

I had then projected the scheme of decomposing the several salts of these bases by transmitting steam over them while subjected to heat. Circumstances prevented my realizing this intention, and in the following year, Mr. Tilghman of Philadelphia, to whom my researches could not have been known, as they had not been published, announced the results of a series of most important experiments—under the head of "Decomposing power of water at high temperatures."*

Mr. Tilghman found that, while a moderate heat was required to decompose sulphate of magnesia with the aid of steam, a higher one was necessary for sulphate of lime, a still higher one for sulphate of strontia, and the highest of all for sulphate of baryta. Thus, their susceptibility to decomposition is in the order of their solubility, viz.—

1.	MgO, SO_3	3.	SrO, SO_3
2.	CaO, SO_3	4.	BaO, SO_3

This research fulfilled my expectations, and it would seem that there can be little hazard in considering the above facts as illustrations of a natural law applying to the group of the alkaline earths.

ART. XXI.—*On the American Prime Meridian;* by Professor J. LOVERING, of Harvard University.

As extensive circulation has been given in the pages of this valuable Journal and otherwise to the views and arguments of those who advocate the adoption of an American prime meridian, it is incumbent on those who entertain serious objections to this important measure to state them fully and frankly; and, if possible, in season to prevent the consummation of a change which they consider uncalled for by the necessities of science and disastrous to commerce. The remarks which I propose to make, at this time, are substantially the same as were prepared in reply

* Chem. Gaz., 1848, p. 181.

to a printed circular addressed to me; which, as it expresses the history of the measure so far as it has yet proceeded, more felicitously than I can hope to do, I take the liberty of introducing here as the preface to what I have to say.

"Cambridge, Mass., Sept. 17, 1849.

Dear Sir,—At the late meeting of the American Association for the Advancement of Science, held at this place, a Committee was appointed upon the subject of an American Prime Meridian, of which you were elected a member.

This committee had its origin in the following circumstances:—

Having been charged by the Hon. William Ballard Preston, Secretary of the Navy, with the duty of preparing for publication the American Nautical Almanac, provided for by the Act of Congress, approved March 3, 1849, I addressed to him a letter concerning the prime meridian to be adopted in the calculation of this work, the selection and determination of which form the first step in my progress.

Mr. Preston, in his reply (dated August 7) to this communication, directed me "to bring the subject of an 'American Prime Meridian' before the American Association for the Advancement of Science, to convene at Cambridge, Mass., on the 14th instant, for the purpose of soliciting the opinions of the principal mathematicians and astronomers upon that highly interesting subject."

In compliance with these instructions, I submitted to the Association a paper,* the same in substance as my letter to the Hon. Secretary, which, upon motion of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, was referred to a committee, consisting of twenty-two members, (whose names are subjoined,) with instructions 'to send a copy of their Report to the Hon. William Ballard Preston, Secretary of the Navy.'

A meeting of as many of this committee as were then present was held, and a sub-committee, consisting of Lieut. Davis, Prof. Bache, and Lieut. Maury, was appointed to conduct the correspondence, and to execute the instructions of the Association.

The persons composing the whole of this committee are so remote from each other as to preclude the possibility of a general meeting to discuss this question, and agree upon any common report; it has been determined, therefore, as the best means of obtaining their views, to address each member of the committee separately.

Accordingly, I have the honor, as chairman of the sub-committee, to transmit to you a copy of the paper presented to the Association by myself, and also of another paper on the Prime Meridian, by Professor Holton, referred to the committee, and to ask your early attention to this communication.

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* See this Journal, viii, 394, November, 1849.

These papers will serve to suggest the principal topics to which your attention is invited, and will, I hope, lead to a free communication of your views and reflections. It is not impossible that the letters of the committee may be hereafter officially called for; you are requested to state, therefore, whether you object to having your letter printed, and, if no objection is given, I shall feel authorized to make it public, if required.

Very respectfully, Your obedient servant,

CHARLES HENRY DAVIS,
Lieut. U. S. Navy, Sup't Nautical Almanac.

Prof. JOSEPH LOVERING, University at Cambridge, Cambridge.

List of the Committee on the Prime Meridian.

Prof. A. D. BACHE, Sup't U. S. Coast Surv'y.	Prof. JOSEPH LOVERING, Cambridge.
Lieut. M. F. MAURY, Sup't Nat. Observat'y.	Prof. WILLIAM SMYTH, Bowdoin College.
Prof. F. A. P. BARNARD, Univ. State of Ala.	Prof. JOSEPH WINLOCK, Shelby Coll., Ky.
Prof. LEWIS R. GIBBES, Charleston, S. C.	Prof. GEO. W. COAKLEY, St. James's Coll., Ky.
Prof. EDWARD W. COURTENAY, Univ. of Va.	Prof. CURLEY, Georgetown College.
Prof. STEPHEN ALEXANDER, Princeton Coll.	Prof. J. S. FOWLER, Franklin Coll., Tenn.
Prof. JOHN F. FRAZER, Univ. of Penn.	Prof. JAMES PHILLIPS, Univ. of N. Car.
Prof. H. J. ANDERSON, New York.	Prof. WM. H. C. BARTLETT, West Point.
Prof. O. M. MITCHELL, Cincinnati.	Prof. EBENEZER S. SNELL, Amherst Coll.
Prof. A. D. STANLEY, Yale College.	Prof. ALEXIS CASWELL, Brown University.
Hon. WM. MITCHELL, Nantucket.	Lieut. C. H. DAVIS, Sup't Nauti'l Almanac."

In reply to this circular, I addressed the following remarks, in substance, to Lieut. C. H. Davis, the chairman of the sub-committee of the Committee of the American Scientific Association on the American prime meridian.

Engagements which could not be postponed have prevented me from giving a more prompt reply to the circular addressed to the committee of the American Scientific Association to whom the subject of the American prime meridian was referred. Having read with interest and attention the papers on this subject communicated to the Association by Lieut. C. H. Davis and Professor Holton, I desire to submit the following remarks.

No other matter presented to the Association at its recent meeting seems to me to compare in practical importance with this. Every one must wish to see the influence of the Association, whose opinion on this subject has been solicited, exerted in the right direction, so as at the same time to promote the interests of science and secure the respect and confidence of the community. It is, therefore, with a feeling of responsibility which I would willingly transfer to those worthier to bear it, that I undertake to offer an opinion upon a subject which involves considerable interests, affects the comfort and safety of a large class of citizens, and perhaps also the honor and prosperity of the country through much of her future history.

The real question I have to consider is whether, after having continued to count our longitudes from Greenwich since we have

had a political existence, we shall now abandon that prime meridian and substitute an American one in its place. The Committee of Congress to whom was referred, on the 25th January, 1810, the memorial of William Lambert, recommended that "in order," as they say, "to lay a foundation for the establishment of a first meridian in this western hemisphere," it is expedient to make provision by law for determining the longitude of Washington and procuring the necessary instruments for this purpose. No action appears to have been taken by Congress on this report of the committee. Although the subject for many sessions was pressed upon the two houses and various reports were made upon it, it was not until the 3d March, 1821, that a joint resolution was passed, authorizing the President to employ means for determining the longitude of Washington. The arguments used on the occasion represent the measure as the preparatory step for the establishment of an American prime meridian, passing through Washington. Nothing, however, was done by Congress at that time which committed it on the latter question. After the resolution just referred to had been carried partially into effect, repeated efforts were made, during the administrations of Monroe and of Adams, to prosecute the subject farther and establish a National Observatory, but without success.

The good sense of the people has kept them in the right track thus far. Occasionally, in our school atlases, the longitudes in the United States are counted from Washington. In these cases, we generally find on the opposite side of the map the corresponding longitudes as measured from Greenwich. In more important matters, as the regulation of chronometers, the construction of sea-charts and whatever relates to geography and astronomy as well as to navigation, the custom is universal of counting our longitudes from Greenwich. Lieut. Maury has followed this custom in his charts of winds and currents, and Professor A. D. Bache has done the same in his maps of the coast, although he also gives the longitudes as measured from some one of the American meridians.

In 1810, the late Dr. Bowditch declared the meditated change of the first meridian from Greenwich to Washington to be inexpedient, as well as extremely difficult if not impossible unless the government incurred the expense of founding an Observatory and publishing a Nautical Almanac. Dr. Bowditch did not object to a Nautical Almanac or a National Observatory, but he considered a good survey of the coast more necessary than either. The liberality of the government has provided in turn for all three. Because in 1810 Dr. Bowditch urged, in addition to other arguments against an American prime meridian, its impracticability for want of a National Observatory and an American Nautical Almanac, and because he declared the establishment of such

an Almanac and such an Observatory to be the only effectual way of bringing an American meridian into use even by our own countrymen, advantage has been taken of this language to prove that, at the present day, this high authority must be considered in favor of an American prime meridian. Such an inference is based on the presumption that whenever any change becomes practicable it is therefore to be desired; and, in the present case at least, it is wholly unwarrantable. Whoever will consult the papers of Dr. Bowditch on this subject in the ninth and tenth volumes of the Monthly Anthology, will be convinced that the principal force of his argument against an American prime meridian, is just as pertinent in 1850 as it was in 1810. With or without an American Nautical Almanac, Dr. Bowditch condemned an American prime meridian as an innovation which would not be "attended with one real advantage."

In a Nautical Almanac, the principal object of which is to give the places of the sun and moon among the stars and planets, at frequent intervals during the whole day, it becomes necessary to select some spot on the earth as the origin of absolute time and the first meridian for longitudes. The superintendent of the American Nautical Almanac is now called on to make his selection. But the establishment and perfect success of an American Nautical Almanac will in no degree be promoted by the selection of an American first meridian, as the basis of its calculations. Lieut. Davis observes: "Our National Observatory at Washington must have existed half a century before it will be able to furnish independent observations sufficient for the determination of a correct theory of the moon or primary planets. But these theories are already calculated from the observations (begun long since and uninterruptedly continued) at the old established observatories of Europe. In preparing new tables I shall avail myself of the Washington observations to the utmost extent of their utility."

Thus it appears that the materials and whatever is most valuable and indispensable for the calculation of an American Nautical Almanac will be and must be borrowed from Europe for many years. I see no reason why we should scruple to reckon from our old prime meridian, even if it do intersect countries to which we lie under such heavy scientific obligations. Certainly, if the British Nautical Almanac is calculated for Greenwich, the American may be also. If both are based on the same identical observations, it can make no difference, either in the dispatch or accuracy of the work, whether the calculations are made at Greenwich or at Washington. Indeed, I think it will appear hereafter that a Nautical Almanac, wherever calculated, which relies on European observations, can be calculated more accurately for an European prime meridian than for an American meridian.

Let us next consider the chief aim contemplated in the establishment of a Nautical Almanac. There can be no doubt that the British Nautical Almanac, at least, was designed for the benefit of seamen exclusively. Before its foundation in 1767, each navigator calculated the places of those bodies which he used in his reckoning for longitude directly from the tables. Thus he was liable to an error of a degree or about sixty geographical miles, in assigning his position at sea. Then it was proposed that the places of the moon and other useful bodies should be calculated from the tables by able astronomers: that these places, corresponding to short intervals during the day, should be published; and that easy means should be furnished for interpolating the place of any one of them at any moment between the hours for which the places are given. As much as possible of the business of navigating the ship was to be anticipated; and as little as possible was to be left to the navigator himself, to be done by him in the hurry and anxiety of the moment. It was supposed, that calculations made under the most favorable circumstances and tested in manifold ways by expert computers, must vastly transcend in accuracy the best that could be made by the most skilful sailor amid the other duties, vexations and perils incident to his profession. Such I believe to have been the design of Nautical Almanacs, whenever and wherever they have been instituted.

The same considerations dictate that no innovations, such as the change of an established prime meridian, whereby fresh perplexities and dangers may be entailed on a profession already too much exposed to uncertainty in every form, should be made without the most clear exhibition of their necessity. I do not suppose that an American sea-captain, qualified to navigate a ship across the Atlantic, is incapable of understanding the relations of different meridians, and of allowing, whenever he compares his reckoning with that kept on board a British vessel, for any difference which may hereafter exist in the established prime meridians of Great Britain and the United States. I only say that this labor, which might generally be done with accuracy, would occasionally lead to mistakes and ought not to be required of the navigator, unless there is some uncontrollable necessity for it. Otherwise, the very class of men for whose benefit an American Nautical Almanac should be designed, will be the most injured by it. I object, therefore, to any change in the prime meridian to which our navigators are accustomed, on the ground that it furnishes new occasion for error, which no one, however careful and however accomplished, can always avoid, and that it introduces a daily inconvenience into the life of every American navigator, and subjects him daily to one new chance of disaster.

Other countries, we are told, in the development of their resources and their science, have established a prime meridian in

their own territories: why should not the United States? The example of the European governments can have little value for us in a nautical point of view. Their commerce on the ocean is comparatively circumscribed; and even did they adopt the prime meridian of Greenwich, they are debarred from a free intercourse with each other and with British and American vessels by a strange language. Besides, in countries where the people, from their habits or their landlocked position, are so much more withdrawn from maritime pursuits than we are, we should expect that their almanacs would consult more the want of astronomers and less the convenience of navigators. There is not one of these countries which is not obliged, as soon as it comes out into the ocean, to defer, to some extent, to the meridian of Greenwich in its use of chronometers and charts; and some, having learned by experience the folly of an assumed independence which worked for them real mischief, have already begun to retrace their steps back to Greenwich.

But our own experience and judgment are worth more than the example of any foreign nations. We speak the same language as the British navigator: why should we be at pains to learn a different scientific dialect? Why should we endeavor to forego all the innumerable advantages we derive from our common origin, and discard an existing agreement in regard to scientific standards which other nations have striven so long and hopelessly to consummate? The communication of Lieut. Davis does ample justice to the importance of an universal prime meridian. There is no reason to believe that a single first meridian can ever be established by the common consent of nations. All desire it, but how many will agree upon the choice? Let us not, in the pursuit of this chimera, adopt the temporary expedient of an American prime meridian, and thus renounce an inheritance to which we were born; throw the whole of this great good to the winds: and postpone, as we must for centuries, the realization of the grand desire of all hearts for a universal meridian. So long as America and Great Britain continue to use a single prime meridian, they alone can make that meridian, for all important nautical purposes, a universal prime meridian, and we at least shall enjoy, not in prospect but in immediate fruition, all the substantial advantages of such a meridian.

The foregoing remarks are designed to show that the adoption of an American prime meridian will violate the spirit in which other governments have established Nautical Almanacs, and will entail upon the commerce of the country, for several generations if not forever, an amount of daily inconvenience and danger which, in the aggregate, cannot be overestimated.

I now propose to consider the reasons that are urged in favor of an American prime meridian. The only reason of a scientific

character which has been given for the proposed change is founded upon the slight error which still affects the best determined American longitudes as reckoned from Greenwich, arising from our ignorance of the exact breadth of the Atlantic ocean. Assuming the uncertainty which still exists in the corrected longitude of Boston to amount to two seconds of time, as stated by Lieut. Davis, this is equivalent to an error of about half a mile in longitude. Half a mile, under the circumstances, is a large error for the astronomer; but to the navigator, who will compare it with other errors to which he is exposed, it will appear quite insignificant. The best chronometers, transported in the British steamers between Liverpool and Boston, are liable to vary four seconds. The errors incidental to the lunar method of calculating a ship's longitude, originating either in errors of the tables or errors of observation, are sufficient to produce an uncertainty, to the amount of ten miles at least, in regard to the position of a ship. The lingering error of half a mile, which still disturbs the longitudes of those American ports whose distance from the continent of Europe is most accurately measured, is small when compared with the fluctuations of chronometers or the doubts which beset the ordinary methods of fixing a ship's position at sea. Whether the error is large or small, important or unimportant, the proposed change of the prime meridian from Greenwich to some spot in America will not contribute in the least to release the navigator from the effects of it. I will suppose a ship which counts its longitude from Greenwich to leave Boston, with its chronometers set at Boston to Greenwich time. These chronometers may differ from true Greenwich time by two seconds, and there may exist an uncertainty to that amount, on arriving upon the European coast, in regard to the precise position of the ship. But when the same ship returns, its chronometers may be set to true Greenwich time. Still the homeward voyage of the navigator will be no surer nor safer than his outward voyage. For, though his chronometers may be correct, he knows not within half a mile the longitude of the port for which his ship is destined. Suppose, the same ship to start again upon another voyage with its chronometers arranged to an American prime meridian. The same difficulties will reappear, though in an inverted order. The captain leaves home with his chronometers set to true American time, but he cannot tell within two seconds the longitude of his European port, and on this account, when he is homeward bound, his chronometers must be stamped by the same error of two seconds. In other words, if we do not know the exact distance from Liverpool to Boston, neither do we know any better the distance from Boston to Liverpool. If the longitudes of American ports as counted from Greenwich cannot be accurately given, neither can the longitudes of any foreign port as

counted from an American prime meridian. The importation of a prime meridian from Europe to our own territories will not, I conclude, operate for the improvement of our navigation.

Neither do I believe that our knowledge of American geography will be advanced by an American prime meridian. The longitudes of a large number of places in the United States have already been determined with great accuracy by the usual astronomical methods or by the transportation of chronometers; and the relative differences of longitude between the principal spots on our coast and those cities and observatories whose longitudes are best known will be assigned through the operations conducted by the excellent superintendent of the U. States Coast Survey. Were all our longitudes to be calculated from observations of eclipses, occultations or transits, so rapidly is the number of observatories and observers increasing over the whole country, there is reason to believe that the capital places in all the states and territories would be determined in this way, if not with absolute precision, with all the accuracy that is wanted for the construction of a correct geographical map of the United States. In this case, however, not only might the absolute distances from Greenwich slightly fluctuate, but the relative distances from each other also. For we could hardly expect that the longitudes of all these places, as measured independently from Greenwich, would be determined with equal precision. We should rather suppose that the meridians most remote from Greenwich and less crowded by population would not, in general, be projected so carefully as the nearer and older meridians. But the transportation of chronometers from place to place will give our relative longitudes independently of any uncertainty as to the exact distance between the eastern and western continents. Thus not only will the relative longitudes be known as accurately as they could be with an American prime meridian, but the absolute longitudes of each and all from Greenwich will be known as accurately as the best; so that, hereafter, though the absolute numbers might change by infinitesimal quantities, the relative numbers will be permanent and our map will be permanent. Moreover, the superintendent of the U. States coast survey has applied with triumphant success the admirable telegraph of Professor Morse to the determination of the longitudes of places intersected by the telegraphic wires. The country is already traversed, in every direction, by the grand telegraphic lines, and these will be crossed in a few years, at a multitude of points, by a finer network. If we wait this short time, our relative longitudes will be ascertained with a precision, a simplicity and an economy wholly unprecedented as yet in the scientific history of any country in the world; and without any reference to our first meridian, whatever it may be. The map and the meridians upon it will never fluctuate. The floating error to the extent of half a mile in regard to the exact distance

between Greenwich and Washington, or any other spot in America, this error or uncertainty in regard to the breadth of the Atlantic ocean on which so much stress is laid, can produce no more derangement in a map of the whole or any part of the United States, than when we push a map from one side to the other of our table. If we desire to unite a map of the United States with a map of Europe so as to form a map of the world, then the uncertainty in question will manifest itself. But no alteration in our prime meridian from one place to another will remove or diminish it; it is absolutely insurmountable. After we have made our map of the United States and drawn the meridians upon it, the selection of numbers to describe these meridians is a question of convenience rather than of scientific accuracy. If we count these meridians from Greenwich, the difference of two numbers will give the relative difference of longitude between the two meridians to which they are affixed. These differences will be permanent, though the absolute numbers may change by some constant quantity, and the differences as well as the absolute numbers may be placed upon our maps and charts if the convenience of those who use them requires it.

I am not able to see that any other scientific operations will be materially affected by the substitution of an American prime meridian for that of Greenwich. I do not see that the details of the American Nautical Almanac or the calculations of those who use it, whether astronomers, navigators or engineers, will be ensured any greater accuracy by the establishment of an American prime meridian. The uncertainty to the amount of two seconds of time in relation to the distance which separates American from European meridians must vitiate, and, as I believe, to the same extent, all our calculations for practical and scientific purposes, until either the uncertainty itself is removed, or we are prepared to make American science in spirit as well as in form, wholly independent of those precious results which centuries of labor have garnered up at the venerable observatories of Europe. If we use an astronomical ephemeris, calculated in Europe for an European prime meridian, or calculated in our own American almanac from European observations and for an European prime meridian, the uncertainty of which I speak, though it does not affect the ephemeris itself, will affect the application of it to our own meridians. On the other hand, if we undertake to calculate an ephemeris for an American first meridian, this ephemeris, though it may be as good when applied to one American meridian as another, will be inaccurate for all, because it has been calculated from European observations. An astronomical ephemeris, calculated exclusively from a long series of American observations would, I doubt not, be better adapted to the wants of American astronomers and serve more effectually the purposes of

American science than any arrangement which can be made under existing circumstances. No one looks more confidently to the future to realize this maturity of American astronomy than I do; and no one, certainly, will more gladly hail it when it shall have arrived. Long before the advent of that happy day, the principal difficulty which American astronomers now experience will have vanished of itself. For it cannot be that the costly and elaborate operations which the government are now conducting under the supervision of the superintendent of the coast survey, with the object of ascertaining with greater nicety the difference of longitude between Cambridge, U. S. and Greenwich, will be of no avail.

I am aware that an American prime meridian would be of some convenience to the single observatory through which it might pass. It is possible that an ephemeris, calculated for that observatory, could be corrected for other observatories on neighboring meridians with a little more dispatch than an ephemeris calculated for so distant a meridian as that of Greenwich. I presume, however, that a little more time and care will ensure as much accuracy in the latter case as in the former. At any rate, if it should appear that the astronomers of the country and others whose pursuits, scientific or practical, require them to handle such an ephemeris, would be essentially accommodated by one which is calculated for an American first meridian, or if it should appear that, in the opinion of those who have charge of our principal observatories or are otherwise most competent to judge, the interests of astronomical science would be materially advanced by such an ephemeris, it may deserve consideration whether one ought not to be provided for their peculiar benefit and that of the science which they cultivate. But, in our desire to promote the science of astronomy, let us not lose sight of the grand aim contemplated in every nautical almanac; but let us make that in fact what it professes to be in name, *a manual for the advantage and security of seamen.*

In conclusion, I must deprecate any attempt to bring about a change in the first meridian used in this country, by a misplaced appeal to our national pride. This is a question, partly of science, but much more of common prudence; into which, if national honor enter at all, it can only be to forbid the contemplated change. Politically, we are independent of all other nations. But in science, literature, and the arts, we must look to the old world for the most perfect models, and long continue to draw from its rich storehouse much that we prize most highly, in thought and action. We are dependent on the old world, and England particularly, as the child is dependent upon the parent, as each generation is dependent upon those which have preceded it and have contributed to its own greatness and glory. No ingratitude or denial on our part will relieve us from this depend-

ence. By the encouragement which we give to the cultivation of true science in this land, and by the bright example which we hold up to the world of a just as well as a free government, we may hope to pay back a part of the great obligation under which we stand to the older nations of the world and the time-hallowed institutions of Europe.

An American prime meridian will make American science independent in name only, and such an independence can deceive no one but ourselves. Certainly, we shall not be so blind as to be deceived by it. Every thing around us must remind us of our relations with the old world. Our ships are furnished with the chronometers and sextants of Great Britain and France. Our observatories are adorned with masterpieces of art imported from Munich. Our libraries are luminous with the great works of Leibnitz and Newton, Galileo and Laplace. We must wait half a century before we shall have created a fund of observations at our own observatories which will make us independent of similar institutions abroad. How much longer must we wait before we shall have American observations made by American instruments? This is a real dependence. Let us not be humiliated by it, but rather let us take courage from it to imitate, in due season, the honorable achievements in science of the older nations of the world.

But the use of a foreign meridian involves no dependence whatever. We do not hesitate to reckon our latitudes from the equator, though this great circle does not, at present, lie within our own territories. Why should we refuse to count our longitudes from the meridian of Greenwich, even if it be a line intersecting some foreign country? We borrow nothing from Great Britain or any other country when we count our longitudes from Greenwich. It belongs to us and to whoever chooses to use it for this purpose, as much as to them. It belongs to us as much as the English language belongs to us and whatever else that is valuable which we have inherited from our parent of the old world. It belongs to us, for all scientific purposes, as much as the earth's magnetism or the sun's light and heat; as much as the moon, planets and stars; as much as the common atmosphere which warms and feeds us all. There is no property in any of these things. They are the common property of all who think, all over the world; and he most possesses who most uses them.

Should Great Britain and America ever agree to adopt an American prime meridian, it would be a misfortune to us. Should the nations ever agree upon a universal first meridian, the prayer of these United States ought to be that it might not pass across this western continent. Of all nations in the world, we can least afford to sacrifice our coasters to the perpetual annoyance they must experience in crossing it. The meridian of New Orleans, which is recommended by Lieut. Davis as the first meridian of

this country, will only furnish a partial remedy for this inconvenience, especially when we consider the new channels opened to our commerce by our enlarged sea-coast on the Pacific. The old maritime nations of the world shifted their first meridian farther and farther westward as their geography and navigation enlarged, that all their commerce might be conducted on one side of it. In this respect also, the meridian of Great Britain is better adapted to the wants of this country than an American prime meridian.

But we cannot expect that Great Britain or any other foreign nation will adopt the American prime meridian. Indeed, it is to be feared that American navigators will not adopt it. They will prefer the British Almanac, calculated for the meridian of Greenwich, to an American Almanac calculated for any other meridian. History declares how difficult it is to effect a revolution in the daily habits of a large class in the community, even where the change is confessedly an advantage to those who adopt it. The change of the prime meridian from Greenwich to America promises no good to any class in the community; it certainly will be attended by great sacrifices and can contribute nothing to our honor or our independence.

The following memorial to Congress, has obtained a large number of signatures in Boston and other seaports of the United States, and been transmitted to Washington.

"The subscribers, merchants, underwriters, and shipmasters of Boston and its vicinity, understanding that a communication has been made by Lieut. Charles H. Davis, of the United States Navy, now charged with the preparation of an American Nautical Almanac, in which it is proposed to change the reckoning of the longitude from the meridian of Greenwich to some place within the United States, beg leave respectfully to submit to you our opinion of this proposed change, and its probable effects upon the navigation of the country.

"The advantages that would result to all commercial nations from marking their longitude from one common prime meridian are too obvious, and have been too often stated, to require any new recital. The evils, however, which might be supposed to result from the great diversity of prime meridians have been of no considerable practical importance to the United States: our navigators have hitherto computed from Greenwich, which, being thus common to them and Great Britain, forms the basis of the longitude of four-fifths of the commerce of the world. This meridian of the English tongue, as it may be called, which is fixed upon all the maps, charts, and books known to our service, it is now proposed to change. We are not possessed, in our own knowledge, of a single good reason for this change; nor can we find any such in the elaborate and ably-drawn argument of Lieut.

Davis. In no single case will the labor of the navigator be abridged, or his knowledge of his place upon the ocean rendered more certain; but, on the contrary, the confusion, incident to the introduction of a new meridian into his books, his charts, and his memory, will be attended with constant perplexity, miscalculation, and mistake, which must cause a serious increase in the hazard of all the lives and property under the American flag.

"Permit us to specify a few of the evils thus predicted:—1*st*, We shall have introduced upon our own coast the east and west reckoning; and although, by making the first meridian at New Orleans, most of the coasting trade will be upon one side of the meridian, yet all vessels passing to the coast of Texas must change their longitude from east to west, and be subject to all the perplexities of that change. 2*nd*, It is now the common practice for navigators at sea to communicate to each other their longitude. This practice is exceedingly useful, and has often led to the correction of errors which must otherwise have been fatal. But this is done in the haste of passing, often in storms and partial darkness,—conditions very unfavorable to hearing and understanding with accuracy even the simple numbers that express the degrees and minutes of longitude. But, if the proposed change of meridian is adopted, another element must be introduced in all communications between English and American vessels, and for a long time between American vessels with each other; and the failure to give the reckoning as from Greenwich or New Orleans, or to hear and understand it rightly when given, may involve ship, cargo, and navigators in one common ruin. 3*d*, A portion of the charts used by United States navigators are, and must continue to be for an indefinite period, of English construction, and consequently marked with the longitude of Greenwich. To reduce this to the American standard upon a sudden emergency, and when perhaps surrounded by danger, cannot be effected, however simple the operation, by all persons, without occasional error; and it must be remembered, that, in these cases, life and death may hang upon the error of a single mile. Some of these evils may be of a temporary nature, which will pass away in a few generations, with the loss of a limited amount of life and property: others, however, must remain, even after the universal adoption of the new reckoning by all the navigators of the United States, and the substitution of books and charts, for all parts of the world, adapted to the new meridian.

"Against all this perplexity and mischief, which must attend the proposed change, its advocates have not *pointed out a single countervailing practical advantage;* but it is suffered to rest, by Lieut. Davis, upon a *supposed* scientific necessity, and upon considerations in some way connected with our national independence.

"Waiving all observations upon the assumed scientific necessity, save the single one that we are unable to perceive that it is

affected in the least degree by the proposed change, we beg leave to add a few words regarding an American meridian, as connected with our national honor or independence. Did we believe it true that the honor or independence of the United States were in the least degree affected by counting our longitude from a meridian line passing through an English Observatory, we would readily encounter all the evils of a change; but we do not believe that any such taint rests upon this practice. We received this mode of counting our longitude, as we received our language, our arts, our names, our very blood, from England, our parent state. The meridian of Greenwich belongs to us, in common with the English nation, by right of inheritance from our fathers, who helped to rear and support the observatory first established there. Our property in this is more clear than in the compass, the chronometer, and many other instruments of navigation; and the same principle of an ideal independence, which shall require us to abandon the meridian of Greenwich, must require us to abandon most of our instruments of art, science, literature, and even our language, for we hold them all by the same tenure; and the question will come to be, not what we shall resign, but what we shall have left. Permit us further to observe, that this state of ideal independence, in marking the longitude, will not be at all attained by the change proposed. It is intended by Lieut. Davis to make the prime meridian *completely dependent upon Greenwich.* It is not to be the meridian of any point arbitrarily assumed at New Orleans, but a line as near as possible to 90 degrees west of Greenwich, which, by a coincidence purely accidental, passes through or near New Orleans. Indeed, the necessities for a continued dependence upon foreign observatories for observations for half a century is distinctly avowed. Without this foreign aid, the proposed almanac could not be prepared. The change, then, will be merely nominal. We shall not reckon our longitude really from New Orleans, but from a point 90 degrees west of Greenwich; and the longitude of Washington, for example, will not be so completely described by saying that it is 12 degrees 56 minutes east of New Orleans, as by calling it 12 degrees 56 minutes east of a meridian 90 degrees west of Greenwich.

"In conclusion, and after a review of the whole subject, we can perceive no reason for abandoning the meridian of Greenwich, or any other of the common property of civilization. If the use of the instruments of art or the methods of science, introduced by other nations, be beneficial to us, the most high-minded and truly independent and national spirit would seem to dictate, not that our practice and usages should be changed, but that we should, by the cultivation and advancement of branches of knowledge, where our efforts can be useful, repay to mankind the advantages which we have received from the common stock of civilization."

ART. XXII.—*On Perfect Musical Intonation, and the fundamental Laws of Music on which it depends; with remarks showing the practicability of attaining this Perfect Intonation in the Organ;* by HENRY WARD POOLE, Worcester, Massachusetts.

(Concluded from page 83.)*

28. THE opinion has been very generally entertained among musicians, that there is a peculiar character belonging to each of the keys. We should not have considered this opinion worthy of notice in this connection, but for the reason that many have attributed this real, or supposed, peculiar character to temperament; for if this peculiarity exists in nature, and is inherent in music itself, it will be especially manifest in a system, or on an instrument, of Perfect Intonation. If, however, temperament is the source of a *variety* which is so highly appreciated by some, it is certainly an argument in favor of temperament, and against Perfect Intonation.

29. We have before us a musical work, of no small reputation, from which we copy the characters, or "complexions," of several of the keys. "C, Bold, vigorous, commanding. D, Ample, grand, noble. D♭, Awfully dark (!) E, Bright, pellucid, feminine. F, Rich, mild, sober. G, Gay and sprightly. A, Golden, warm, sunny. A♭, The most lovely of the tribe; unassuming, gentle, soft, delicate and tender, having none of the pertness of A in sharps. B, (in sharps) keen and piercing. B♭, the least interesting of any, &c., &c." These ideas have been formed and perpetuated by a sort of musical creed, and is said to have for its authority, "the common consent of musicians." It is not so much our purpose to oppose this beautiful theory, as to show, that no argument can be drawn from it to sustain temperament. If temperament be assigned as the cause why the key of A differs in character from the key of A♭, the difference must be found in the fact that one is tempered differently from the other. If tempera-

* In our article in the last No. of the Journal, we gave a brief account, so far as we were informed, of all the attempts that have been made to attain *Perfect Intonation*. Since the January No. was issued, our attention has been called, with no little surprise, to a recent No. of the Westminster Review, vol. 50, page 253, Am. ed., in which an allusion is made to an improvement in the organ, similar to ours, which has recently been brought out in London, by Col. P. Thompson. Of the details of Col. Thompson's invention we know nothing, as our knowledge is entirely confined to the notice referred to, and there it is alluded to, simply to illustrate some truths, of which we are now endeavoring to convince the American public. It might have appeared remarkable that the same invention should have been made at the same time, after the subject had been reposing so quietly for forty years—the parties being so remote and knowing nothing of what the other was doing—if the history of science did not furnish even more remarkable instances of the kind. If the invention in England is as successful as ours, it will illustrate this simple truth, that, in the course of human events, the time for *Perfect Intonation* has arrived.

ment was adjusted in any uniform manner, through the different classes of instruments, and by different tuners, there would be a show of argument, in the fact, for temperament. But we find no such uniformity; different instruments are tempered in a widely different manner; and on one instrument the key of A is tempered like the key of A♭ on another. If an instrument be tuned in the *equal temperament*—which is the more common and popular—every key is tempered *precisely alike*, and consequently all peculiarity from the cause assigned will disappear. If an alteration of *pitch*, either, be the cause, as some have supposed, of this peculiarity in the different keys, as instruments often vary from one another, in pitch, a semitone, it will often be difficult to decide which is the "soft and tender" key of A♭, and the "pert" key of A. If an organ be tuned correctly in the key of A♭, (or four flats,) and the temperature of the room rise a few degrees, the relative pitch of the whole organ will rise a comma, and the music played in the key of *four flats* will have the *character* (if this theory be correct) of the key of *eight sharps!**

30. Undoubtedly, in perfect intonation, a certain key is frequently more appropriate for a given composition than any other key; but that a certain key gives to music performed in it, any such peculiarity as we have quoted, is (in our opinion) as fanciful as to suppose that the size of the canvas determines the character of the painting. We will suppose a composer has an idea which he would express in a soft and gentle air; thinking that the character of A♭, renders it the most appropriate key for the expression of his idea, he writes his music in that key and arranges it for a quartette. He executes the music, thus arranged, on his piano-forte, and the soft and gentle effect desired is produced. He then gives it to a quartette to perform, without any accompaniment. They take their pitch a semitone higher than his A♭, that is, exactly in his "pert" key of A. Would the composer

* There is something so very imaginative in this theory of the different keys having different characters, that one might reasonably doubt whether such a theory had any supporters. Such however, we are compelled to say is the fact—it is found in the books, and is taught at the present day, by many teachers of reputation. If any one still doubts the fact, we would refer him to a recent number of the London Quarterly Review, vol. 83, p. 274, Am. ed., where, in an elegantly written article on "Music," the characters and complexions of the several keys afford the writer a theme for many sublime remarks, as if the theory had never been questioned. "A whole Bridgewater treatise" this writer says, "might have been not unworthily devoted to the wonderful varieties of keys alone. He [the composer] knows whether he requires the character of triumphant praise given by two sharps, as in the Hallelujah Chorus of Handel, or the Sanctus and Hosanna of Mozart's Requiem; or the wild demoniac defiance (!) of C minor, as in the allegro of the Freischütz overture; or the enthusiastic gladness of four sharps, as in the song of *Di Piacer*; or the heart-chilling horror (!) of G minor, as in Schubert's Erl King, and all the Erl kings that we have known." A very proper reply to this writer in the Quarterly, can be found in an article on "Greek and Modern Notation of Music," in the volume of the Westminster, to which we have already referred in a previous note.

himself perceive any difference in the effect of his music? We think not; and say moreover, with confidence, that no one, in listening to an instrument, to the pitch of which he is not accustomed, can, with any degree of certainty, decide in what key the music is played. A flute-player may judge correctly as to the key, when listening to an air performed on his own flute—perhaps a flute to which he is not accustomed—for different tones on the flute have different qualities; the high E, for instance, has a different quality from the E♭; but this is admitted to be an imperfection in that instrument, which art has endeavored to obviate. The character of music depends on other things than the *key* in which it is written. Many "soft and tender" compositions have been written in A♭, and many of an opposite character.

One key is more appropriate for a composition than another, for the reason that there will be employed in that key, a range of sounds which are best adapted to the quality and compass of the voices, or instruments, for which the music was composed. Thus if a melody of this compass, (an octave and a fifth,) were written for a soprano or tenor voice, it would not probably be placed in the key of C, as in that key the highest notes would be too high, and the lowest notes too low for convenient execution. Such a melody would more appropriately be placed in a key in the vicinity of F. Assuming F to be the *best* key for it, we believe that the nearer the key is brought to F, the better will be its effect; that is, the key of D will be better than C, E♭ than D, and E better than E♭. Melodies of small compass may be adapted to several keys. In different collections of music before us, the Hundredth Psalm—whose melody is contained in the compass of an octave—is written in four different keys, viz., F, G, A♭ and A.

31. It is necessary to examine more particularly than we have yet done in this paper, the subject of TEMPERAMENT, if we would fully understand how far the scale of the common organ, with twelve notes in the octave, when arranged in the best possible manner, falls short of fulfilling the requirements of music. As we shall have frequent occasion to refer to a table we gave in the January No. of the Journal, (25.) we reinsert that table, (see next page,) for the convenience of those who may not have that No. at hand. It was shown in (11.) that *four prime intervals* are employed in music, viz., the *octave*, *fifth*, *major third* and *perfect seventh*. It

appears from the table that notes which vary by smaller intervals than a semitone, result from combining these four prime chords. In temperament, these four chords are disposed of in the following manner. The *octave* is tuned perfect. For the *perfect seventh*, no provision is made, and it is rejected altogether. The *thirds* and *fifths* remain, to which alone temperament is applied.

Signatures.	Key Notes.	Major Seconds.	Major Thirds.	Dominant Sevenths.	Perfect Fourths.	Perfect Fifths.	Leading notes, Minor scales.	Major Sixths.	Perfect Sevenths.	Major Sevonths.	Octaves.
5 Sharps.	B^3	$C\sharp^3$	$D\sharp^2$	E^7	E^3	$F\sharp^3$	F^{+1}	$G\sharp^2$	A^7	$A\sharp^2$	B^3
4 Sharps.	E^3	$F\sharp^3$	$G\sharp^2$	A^7	A^3	B^3	$B\sharp^1$	$C\sharp^2$	D^7	$D\sharp^2$	E^3
3 Sharps.	A^3	B^3	$C\sharp^2$	D^7	D^2	E^3	$E\sharp^1$	$F\sharp^2$	G^7	$G\sharp^2$	A^3
2 Sharps.	D^2	E^3	$F\sharp^2$	G^7	G^2	A^3	$A\sharp^1$	B^2	C^7	$C\sharp^2$	D^2
1 Sharp.	G^2	A^3	B^2	C^7	C^2	D^2	$D\sharp^1$	E^2	F^7	$F\sharp^2$	G^2
Natural.	C^2	D^2	E^2	F^7	F^2	G^2	$G\sharp^1$	A^2	$B^{\flat 7}$	B^2	C^2
1 Flat.	F^2	G^2	A^2	$B^{\flat 7}$	$B\flat^2$	C^2	$C\sharp^1$	D^1	$E^{\flat 7}$	E^2	F^2
2 Flats.	$B\flat^2$	C^2	D^1	$E^{\flat 7}$	$E\flat^2$	F^2	$F\sharp^1$	G^1	$A^{\flat 7}$	A^2	$B\flat^2$
3 Flats.	$E\flat^2$	F^2	G^1	$A^{\flat 7}$	$A\flat^2$	$B\flat^2$	B^1	C^1	$D^{\flat 7}$	D^1	$E\flat^2$
4 Flats.	$A\flat^2$	$B\flat^2$	C^1	$D^{\flat 7}$	$D\flat^2$	$E\flat^2$	E^1	F^1	$G^{\flat 7}$	G^1	$A\flat^2$
5 Flats.	$D\flat^2$	$E\flat^2$	F^1	$G^{\flat 7}$	$G\flat^2$	$A\flat^2$	A^1	$B\flat^1$	$C^{\flat 7}$	C^1	$D\flat^2$

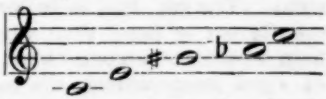
The principle on which it is applied will be seen by the following example. In the table there appear two E's, one obtained by turning a major third from C^2, viz., E^2, and the other, E^3, a comma higher than the first, obtained by tuning a series of *fifths* from the same C^2. It is proposed in temperament to use *one* E for these *two*. It is evident that if E be tuned truly as a major third it will be a comma too flat, in a series of fifths; and also, if it be tuned truly in a series of fifths, it will be a comma too sharp, as a major third. As the error of a comma is *intolerable*,* if occurring in one place, it is usually divided among the four fifths, and

* In correcting opinions on this subject, which, we think, are erroneous, we have already, and shall again refer to Prof. Peirce's treatise "on Sound;" not because the views, to which we take exception, are peculiar to, or original with him. They are also found in other works of the kind of high authority. We have referred to Prof. Peirce's treatise because it is more common, and the learned Professor is at hand to correct us if we err. In treating *Temperament*, in § 108, he says, "The principle on which the reduction of notes is made, is, that if the notes differ from each other by only one vibration in eighty, [or a comma,] the ear can hardly perceive the difference between them, and the substitution of one of them for the other, will not be fatal to harmony." This is another point which the *ear* must decide, and we must set against the Professor's authority not only our own, but the experience of every tuner. Instead of the error of a *comma* being an interval so small that "the ear can scarcely perceive the difference," *a twelfth of a comma* can be, and is, perceived by every intelligent tuner, as this is the interval by which he leaves the fifth flat, in the equal temperament. But a fifth a *whole comma* flat, or sharp, is probably as *discordant*, and "fatal to harmony" as any possible interval.

the major third. By flatting the fifths, the third is prevented from being so sharp, as it would otherwise be; and sharping the third, will, in like manner, benefit the fifths. Temperament, therefore, is a compromise between the thirds and the fifths, in which each gives up more or less of its purity, in order to favor the other series of intervals.

32. Although temperament may be adjusted in many different ways, yet every possible adjustment can be classified under one, or both, of two general systems, called the MEAN-TONE SYSTEM and EQUAL TEMPERAMENT. The first aims to preserve the perfection of the thirds; while the latter sacrifices the thirds, and gives preference to the fifths.

33. The first is called the MEAN-TONE SYSTEM, for the reason that, instead of preserving the distinction between the major tone of *nine commas*, and minor tone of *eight commas*, it averages the two, and makes a MEAN-TONE, of *eight and a half* commas. Consequently the sum of two *mean-tones* equals the sum of a major and minor tone, or a perfect major third. In tuning the E in this temperament, it is tuned a perfect major third from C, or E^2, as we express it, in the table. This E not being high enough, by a comma, for the E in the series of fifths, the error is divided equally among the four fifths, viz., C to G, G to D, D to A, and A to E, and each is left flat by a *quarter of a comma*. The tuning is continued until *eight* notes have perfect major thirds, and fifths that are a quarter of a comma flat. These are all the chords that can be used in an instrument of *twelve* notes in the octave. In this system, a *sharp* cannot be used as a *flat*, as it will be false by the *enharmonic diësis*, or about two commas. This is the interval by which three major thirds fall short of the octave, and it is obtained in this manner. Commencing with C, we tune E, a perfect major third, from this E, tune G♯, a major third; and from C, an octave above the first, tune downward a major third to A♭. This A♭ is not as low as G♯, by the *diësis*, and G♯ will not answer at all for A♭. When common organs, which have but one sound for G♯ and A♭, are tempered on this system, one of these



notes, usually A♭, is left so false that it cannot be used. Some organs have an A♭ supplied by a different pipe. The Temple organ, in London, has two notes thus supplied, A♭ and D♯, by the aid of which, that instrument is enabled to play in two scales more than those, tuned in this temperament, which have but twelve sounds in the octave. The mean-tone system bears, in many respects, more resemblance than any other temperament, to the perfect scale. It recognizes a distinction between sharps and flats, diatonic and chromatic semitones, has perfect major thirds, and has its minor thirds nearer to perfection, than in any

other temperament. With these advantages, however, it is justly censured for its discordant fifths, and its "wolfishness" when the modulation is carried into keys, where it is not prepared to play.

34. The EQUAL TEMPERAMENT preserves the fifths nearer to perfection than the mean-tone system, and consequently throws the discord, or "wolf," (as it is termed by tuners,) into the thirds. The fifths, however, although they are favored, are yet not given in perfect tune. It is found in perfect tuning, that a series of twelve fifths will end a comma* higher than the note commenced with. In equal temperament, it is designed to make the series meet, and consequently this comma is equally divided among the twelve fifths, leaving each a *twelfth of a comma* flat. If this be accurately done, the octave will be divided into twelve equal parts, and one fifth will be equally as good (or bad) as another. To set this temperament, it is only necessary to temper the fifths carefully, as has been stated, without regarding the thirds at all. The major thirds will be found sharp, by an interval eight times as large as the error in the fifths, that is, *two thirds* of a comma. The minor thirds will be flat *three fourths* of a comma, or the sum of the temperament of the fifth and the major third. As it is designed, in the equal temperament, to have every chord of the same name, equally tempered, the necessity of leaving the thirds in this condition will be further made obvious. The third part of the octave must be used as a major third, and as three *perfect* major thirds do not equal the octave by the *diësis*, each third must be sharped, by one third of the *diësis*, or *two thirds* of a comma. Again, the minor thirds must be each, one fourth of an octave; but four *perfect* minor thirds overrun the octave by *three* commas; this excess therefore is equally divided among the four minor thirds, and each is left flat, by *three fourths* of a comma.

35. The Equal Temperament has this great advantage over all others—its twelve keys can all be used, they are all tempered alike. The ear, too, is better satisfied when all the chords are *equally out of tune*, than when it listens to constant transition from a better to a worse chord. It can also be demonstrated that in equal temperament, the *sum* of the temperament of all the chords—if the instrument be used in the twelve keys—will be less than in any other. Any other than the equal system, is simply an attempt to improve part of the thirds, by sacrificing, not only the fifths, but the remaining thirds.

* This comma, which is called the *Pythagorean comma*, results from combining the octave and fifth, which are derived from the primes 2 and 3; and consequently cannot be mathematically the same as the *comma* before mentioned, resulting from the fifths and thirds, or the primes 3 and 5. The ratio of the last, as before stated, is 80:81; the ratio of the *Pythagorean comma* is 524288:531441 or 80:81,091463091068+. It will be seen that the two commas are very nearly the same, and to consider them the same, will greatly simplify the subject of temperament, while it will not involve any material error.

36. The following table will exhibit the temperament of the principal chords and intervals in the two systems.

	EQUAL TEMPERAMENT.		MEAN-TONE SYSTEM.	
Fifths,	$\frac{1}{12}$ of comma	Flat.	$\frac{1}{4}$ of comma	Flat.
Fourths,	$\frac{1}{12}$ " "	Sharp.	$\frac{1}{4}$ " "	Sharp.
Major Thirds,	$\frac{2}{3}$ " "	Sharp	Perfect.	
Minor Sixths,	$\frac{2}{3}$ " "	Flat.	Perfect.	
Minor Thirds,	$\frac{3}{4}$ " "	Flat.	$\frac{1}{4}$ of comma	Flat.
Major Sixths,	$\frac{3}{4}$ " "	Sharp.	$\frac{1}{4}$ " "	Sharp.
Perfect Sevenths,	$1\frac{5}{12}$ " "	Sharp.	$1\frac{3}{4}$ " "	Sharp.
Major tones and Ninths,	$\frac{1}{6}$ " "	Flat.	$\frac{1}{2}$ " "	Flat.
Minor Tones,	$\frac{5}{6}$ " "	Sharp.	$\frac{1}{2}$ " "	Sharp.
Diatonic Semitones,	$\frac{7}{12}$ " "	Flat.	$\frac{1}{4}$ " "	Sharp.
Chromatic Semitones,	$\frac{5}{12}$ " "	Sharp.	$1\frac{1}{4}$ " "	Flat.
Grave chro. Semitones,	$1\frac{5}{12}$ " "	Sharp.	$\frac{1}{4}$ " "	Flat.

37. If we extend the science of music and musical ratios beyond the limits referred to in (8.) the errors from temperament, in the mean-tone system, will be increased by the addition of the diësis. As no provision is made in either system of temperament for the chords of "perfect sevenths," it will be seen from the table that they will be extremely harsh, being false by about a comma and a half. These two systems embrace every advantage that can be found in any, and every intelligent tuner knows that no mixed system embraces advantages beyond either of the original temperaments. It is the quack and pretender only, who professes to unite in one system the advantages of both; in other words, to favor the fifths, as they are in the *equal*, and the thirds, as they are in the *mean-tone* system. It is certain that no new system of tempering twelve sounds, so that they will perform correctly the office of several times that number, has been discovered during the last century, and we think we have shown that such a system never will be discovered, while the laws of nature and the mathematics continue the same.

38. In whatever manner the temperament is set, the best chords are given imperfect, and this imperfection is so obvious that the common ear, entirely unskilled in music, can most readily distinguish between chords that are tempered, and those that are *tuned perfectly*. We are so constituted, however, (and wisely so, of course,) that we can get accustomed, in time, to almost any amount of discord, so that it will not be, to us, disagreeable. It is said that men, whose whole lives are spent in riveting the plates of steamboat boilers, perceive no discord in the harsh clangor of their business. Such artists would probably *prefer* a tempered organ. It is for the natural and uncontaminated, as well as for the cultivated, ear to appreciate fully the beauty and perfection of pure harmony. The best tuners, in our large manufactories are free to confess that there is but little musical satisfaction in leaving

an instrument, which has been constructed carefully in all its parts, *out of tune.*

Notwithstanding the evidence of our senses, that the perfect scale is most pleasing to the ear—notwithstanding the sure deductions from the mathematics, there are those who speak and write against perfect intonation. "Why," it is asked, "if it was intended, in nature, that music should be in *perfect tune*, has a tempered scale been used for so many centuries?" Admit such an objection, and there is an end of all invention and discovery, in this, and every other science. Against the greatest invention of the age—the electric telegraph—the same objection has equal force. So long as no mechanism had been invented, by which more than twelve sounds could be conveniently managed by the performer, we should naturally suppose that organ-builders would manufacture such instruments as we have, and give to them the best tune they could, even if it was somewhat imperfect; but we might *not* have expected, that learned and professedly scientific writers should have attempted to prove, from this fact, that the *nature of music* does not permit its chords to be in *perfect tune.** It has *not* been customary, so far as our information extends, for those

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* Prof. Peirce again says, §115, "It is a mistake to suppose, as some have done, that temperament applies only to instruments with keys and fixed scales. Singers, violin-players and all others who can pass through every gradation of tone, must all temper, or they could never keep in tune with each other, or with themselves."

"Any one, who should keep on ascending by perfect fifths, and descending by octaves and thirds, would soon find his fundamental pitch grow sharper and sharper, till he could at last neither sing nor play; and two violin-players accompanying each other and arriving at the same note by different intervals, would find a continual want of agreement."

With regard to the statement in the first paragraph, we shall now take occasion only to say, that the reverse we believe to be true; and it appears to us contradictory, to assert that singers, to sing *in tune*, must sing *out of tune*, (for this is precisely the meaning of temperament.) If the learned Professor will visit our instrument in Boston, we will satisfy him that, with our instrument as an accompaniment, which does not *temper* in the least, singers find no difficulty in keeping *in tune*.

The second paragraph probably refers to a case like the following, which has often been quoted by those who advocate temperament. "If from C we ascend by four perfect fifths and descend by two octaves and a major third, we find the last note a comma higher than the C commenced with." This is entirely true. Neither can we multiply a number by $\frac{3}{2}$'s, and divide the product by $\frac{2}{1}$'s and $\frac{5}{4}$'s, and reach at length the original number; for this reason, nevertheless, the Professor does not advocate a *temperament* in the mathematics. The supposed trouble with the violin-players who arrive at the same note, by different intervals, is, that they will *not* arrive at the *same note*, but different ones; for if one ascends from C, by *four fifths*, he will arrive at a different note from the other, who ascends from C, by a major third. The first would find himself in four sharps, while the other would be in the natural scale. The first would be playing (as we express it) E^3, the second E^2. The trouble is of the same nature as if two players should attempt to reach the same note, by ascending, one a fourth, and the other a fifth, from the same key-note. But no music requires either of these impossibilities to be done.

It was perfectly proper to treat of *temperament*, in a scientific work of this kind, as showing the best that could be done with twelve sounds, but we think it is to be regretted that imperfections should have been attributed to *music as a science*, which pertain only to the construction of musical instruments.

who profess to treat the *natural sciences*, to charge *nature* with *imperfections*, but rather, if possible, to discover order and system, where only apparent imperfections were visible. Perhaps scientific writers on music are the only exception to this rule. These imperfections, however, belong entirely to their theories, and have no existence in the nature of music. No science—not even the mathematics—can be more *perfect* and harmonious than music, in the department which relates to intonation.

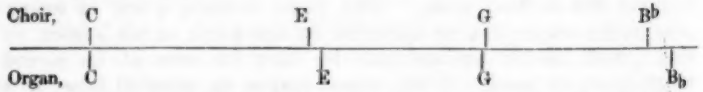
39. But melody and harmony do not produce all the effect of music, for much depends on the quality of tone, rhythm, expression, &c. It is therefore possible that tempered music may be pleasing, if good in these last particulars, although its melody and harmony be imperfect. But it is certain that, *cæteris paribus*, the more perfect the intonation, the more pleasing will be the music. The importance of absolutely perfect harmony is not equally felt in all kinds of music. In dance music, for example, the *rhythm* stands prominent, and although even here the music would be best if performed *in tune*, still, in quick movements, and in the rapid flight of notes, the attention is diverted from the imperfection in the intervals.

40. Church music, perhaps more than any other, depends, for its excellence, almost entirely upon its *harmony*. From church music, are necessarily excluded many qualities which add much interest and character to other kinds of music. As its movement is slow and regular, any excellence or defect in its harmony is most apparent. The instrument which has long been used, and is best adapted as a guide and accompaniment to voices in church music is *the organ*. For this purpose it is *the instrument* of all instruments, as its derivation (*τὸ ὄργανον*) also signifies. It is superior to all others, in the volume of sound and number of parts which can be brought under the control of a single player—it excels in keeping in tune, and can sustain steadily its sounds for any length of time—it will give its sounds, also, with a certainty which even violins cannot always attain. For although these stringed instruments admit of perfect intonation, yet it requires a skill, which very few artists possess, of always striking at once the desired note. The exact relative pitch of every pipe in the organ can be adjusted by the tuner at his leisure, so that (with proper precautions) he may be sure of its sound whenever it is used. If the tuner leaves an interval false, it is beyond the power of the organist to improve it; in this respect, the violin has an advantage over the organ, for if a string of the violin fall from its true pitch, skill of the artist, in execution, can overcome the difficulty.

41. *Perfect tune* has been for centuries the great desideratum in the organ and instruments of this class. In the tempered organ, the tuner leaves no chord, except the octave, in perfect tune, and

hence whatever the best organist attempts, must be imperfectly done. So long as the organ is used only as a solo instrument, as for a voluntary, a skillful performer is able in some degree to cover up the great imperfection in its tune. By great rapidity of movement, and incessant and startling transitions from key to key, he may divert the ear from criticising the imperfection of the chords. Temperament has doubtless done much to form a style, so prevalent at present among organ players and composers for that instrument—a style neither dignified nor scientific. Organists and composers are not to be blamed for this faulty style, (or a style which *would* be faulty, if their instruments could play in tune;) for being unable to obtain legitimate harmony, and satisfy themselves, or their hearers, with dignified compositions—which show most conspicuously the defects of a tempered instrument—they resort to other expedients to please, and they astonish their hearers with remote and wonderful modulations, and feats of execution.

42. When played with the choir the defects of the organ are most perceptible. As the organ usually plays the same parts which the choir sing, the singers must temper exactly like the organ—which probably no choir was ever trained to do accurately—or there will be a continued want of agreement between them. A *perfect* major third, a child, who has had no musical instruction, will strike most readily and almost unconsciously, for it is in the simple ratio of 4 : 5, and the ear instantly detects the coincidence of the vibrations; but a *tempered* major third, *two-thirds of a comma sharp*, he knows nothing about; it requires the skill of a scientific and well-drilled musician, to give it correctly. If the singers could learn to temper with the organ, it would be at the sacrifice of that pure harmony which they would make if they sung in tune without a tempered accompaniment. The ordinary agreement, (or rather *dis*agreement,) between a choir and organ accompaniment, can be illustrated to the eye by the following example. We will suppose that an organ, tuned in the equal temperament, is accompanying a choir, when it is singing the common chord of C.



The key-note of C will, of course, be the same in the organ and the choir. The fifth G, of the organ will be slightly, but percetibly, flat, viz., one twelfth of a comma. The third E, of the organ, will be very discordant with the choir, being two-thirds of a comma sharp. If B♭, in the chord of the seventh, be added, the discord will be much greater than in either the fifth or the

third, the organ being a comma and a quarter too sharp.* The discord is more conspicuous when the organ plays the vocal parts, as above, than when it plays a separate accompaniment, as is sometimes done. A tempered instrument, as a piano-forte, may be properly used in this manner, as an accompaniment only, without impairing materially the perfection of a melody, which is sung by a voice.

43. For many reasons, some of which we have stated, it has long been believed by musicians, that if the organ could be constructed to play in *perfect tune*, and could be managed by the organist, it would be exceedingly valuable for aiding the songs of sacred praise in our churches. It would afford to singers a certain guide and test, and would harmonize perfectly with their voices, when they sing in a manner most satisfactorily to themselves and to all who hear. Having ascertained the notes which are necessary to perfect a requisite number of scales, it would not be difficult to construct an organ with pipes which will give all these sounds, and a wind-chest containing the proper number of valves. But these sounds must be under the ready control of the organist, or the instrument is impracticable. If we represent each sound, on the key-board, by a separate finger-key, an insuperable difficulty in execution presents itself; and it is useless to talk of what the key-board *might* have been made originally. Universal custom has fixed the key-board, and it would be as impossible now to change it, as to introduce a radical change in the orthography of our language. It remains, therefore, to invent such mechanism that the organist, with a common key-board, can conveniently control the sounds which are required to perfect every musical scale, in which the instrument plays. As these difficulties of mechanism have been successfully overcome recently in an instrument, to which allusion has already been made, a brief notice of it may be proper in this place.

44. This instrument, the EUHARMONIC ORGAN, invented and built by Joseph Alley of Newburyport, Mass., and the writer of this paper, is now set up in Boston, and will be exhibited, with pleasure, to all who may take an interest in the progress of musical science. It plays perfectly within the limits of five sharps and five flats, both inclusive. The theory of the instrument renders it perfectly practicable to construct one of any size, or compass of modulation, even to twenty sharps and twenty flats, if de-

* Any one, who will notice the singing of a good quartette with a tempered organ, may perceive the variation and discord of the organ upon these thirds and sevenths, particularly the last. For this reason these notes are oftentimes omitted, as in chants, to the great improvement in the general effect. Good natural singers, who give their thirds and sevenths correctly, on first singing with an organ, have been accused by organists and conductors ignorant of the matter, of singing *flat*, because by temperament these notes on the organ were *too sharp*.

sired; but it is very rare that we meet, in church music, with a more remote modulation than is provided for in this instrument. The key-board, and the method of fingering, are the same as on the common tempered organ, and the only addition to the player's duties, is the management of certain pedals which must occasionally be pressed, when the music modulates into a different key. The object of these pedals is to enable one finger-key to open either of two or more valves. For example, if the C♯ (or D♭) finger-key be pressed when the music is in the scale of *one flat*, the note wanted is C♯¹ the leading note to D minor, (see the table;) but if the music is in the scale of *four flats*, a different note, D♭², is wanted and is given by the same finger-key. The A finger-key opens, in the scale of C, the valve to A², and the same finger-key opens, in the scale of G, the valve to the pipe A³. These pedals are equal in number to the scales or *signatures* in which the organ is designed to play—each pedal belongs to a certain signature, and they are arranged in their natural order, as follows:

MODULATION PEDALS,

&c., 5♭, 4♭, 3♭, 2♭, 1♭, ♮, 1♯, 2♯, 3♯, 4♯, 5♯, &c.

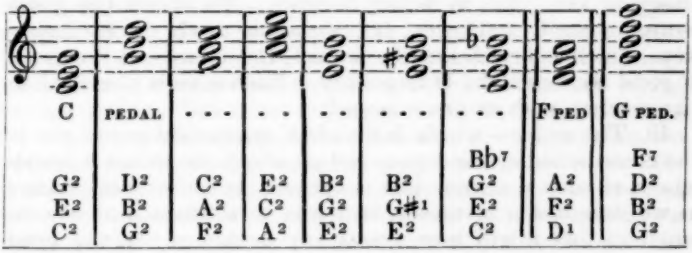
By pressing any one of these pedals, the action is brought into such a position, that the finger-keys will act on those valves (and no others,) which are required in the scale to which the pedal belongs. The act of putting down any pedal will always draw up any other which may be down at the time, and will detach from the finger-keys every valve not wanted in the scale required.

45. To illustrate the practical operation of the organ, we will take a tune, which is entirely in one diatonic scale, as the "Hundredth Psalm" in the key of G. On putting down the 1♯ pedal, the organ is in readiness to play. The valves of the pipes belonging to the scale of G, are connected with the proper finger-keys, and all others are detached; consequently, the playing of this composition on the euharmonic, will be the same as on the common organ. This however is a simple illustration, and before we explain a more complicated one, we must speak further of the plan of the instrument.

46. As but seven, of the twelve, finger-keys are employed to play the diatonic scale in each key, to the remaining five finger-keys are brought on and attached, by the same pedal and at the same time, five other notes, which are set down in the table as "leading notes of the minor scales" and "perfect sevenths," and three others which belong to the adjoining scales. In each pedal will be found the following chords, viz., the tonic, the dominant, and subdominant—the chord of the relative minor (the sixth of the scale,)—the chord of the mediant (the third,)—the major chord of the dominant of the relative minor—and the chord of the sev-

enth upon the tonic. So long as a composition uses no other chords than these, there will be no necessity, of course, to change the pedal. But most compositions either modulate into the adjoining key, (usually the dominant,) or at least pass into an adjoining scale, by using chords which belong to that scale. When a complete modulation is made, it is so apparent in the written music, that no musician of ordinary intelligence can fail to know it. But as certain chords are *borrowed* from an adjoining scale, without a complete modulation being made, and without the change being indicated by accidentals, the whole difficulty in playing the organ, will be in not understanding when these chords occur. A little attention to this point will make it perfectly clear.

47. The chords referred to are only two, viz., the *chord of the relative minor of the subdominant*, and the *chord of the dominant seventh.* The first chord will be found in the *subdominant* pedal—the first pedal to the left; the second will be found in the *dominant* pedal—the first pedal to the right. Examples of the chords we will write in the key of C, including the two last, which would be likely to occur in a composition in that key; we will write also the notes, which compose each chord, and the pedals in which each are found. The chord of the relative



minor of the subdominant, is founded, *not* upon the *second* of the scale, but upon the *sixth of the subdominate scale*, which note is a comma lower than the second of the scale, and is called the *grave second;* and this chord is called, for brevity, the *chord of the grave second.* In the example, it will be seen that the only reason for pressing the F pedal is to change the second of the scale of C, viz., D^2, into the *grave second*, D^1, the sixth of the scale of F. Again, in the chord of the dominant seventh, the G pedal is put down to change the fourth of the C scale, F^2, into the perfect seventh of the G scale, F^7.

48. All other chords, than these two, occurring in music, which require a change of pedal, are indicated in notation by *chromatics:* and it is believed that what has already been said is sufficient to enable any one, who possesses sufficient knowledge to play the common organ understandingly, to play the euharmonic organ.

That many who now assume to play the organ in our churches, would find difficulty in playing their music and making the requisite changes with the pedals, we have not the shadow of a doubt. To such we would recomend a course of study, on the scientific principles of music; but that any intelligent organist can readily make these changes, after a few hours' practice, has now been abundantly demonstrated. By practice, the organist will find that the music can be played with much fewer changes of pedals than he would probably make at first. He will find, for instance, that when the dominant seventh is followed by the tonic chord, it will not be necessary to change to the tonic pedal, as both chords are in the dominant pedal. It will be found, again, that the change of pedal, which would otherwise be requisite, to perfect the chord of *grave second*, can be dispensed with, by an arrangement in one action, provided for that purpose. As the first finger-key, below that used for the *second* in the scale, is unemployed, we have attached to it the *grave second*, which is a comma lower than the *second*. When therefore this *grave second* is required, it may be obtained, without touching the pedal, by placing the finger on the first key below the one which gives the *second*. It can be obtained also by the usual fingering—if the player prefers—by changing the pedal as before directed. To obtain the *grave second* of the C scale, viz., D^1, we either touch the Db finger-key, which is first below the second, D^2, or we put down the F pedal and touch the D finger-key. Each scale is furnished, in like manner, with its *grave second*.

49. The action—which is the chief mechanical peculiarity in the construction of the organ, and on which the patent is founded—is of such a nature, that it operates as perfectly in practice as we designed it in theory, and it is so substantial in its construction, that it will bear almost any amount of use, and stand almost any number of years, without getting out of order, or needing repairs. It can be applied to the largest instruments, as those which contain the four organs, viz., the Great, the Swell, the Choir, and the Pedal Organs; a single set of pedals will operate, as described, upon the whole at once.

Much of this paper we have devoted to considering, *what sounds are necessary to a certain number of perfect scales?* On these points we have asked not so much, what is *authority?* as, what is *truth?* We have been compelled to differ from teachers in this science, to whom we look up with veneration and respect. So far as our views on these points are original, we commit them, without anxiety, to the world, to share such a fate as their merits deserve. But a distinction must be made between our *theory*, and our *invention*. The value of our invention will not be endangered even if our theory of the musical scale should fail. Our instrument plays the scale which we believe to be correct.

Our mechanism, however, is as well adapted to play any other scale, as the one we have adopted.

The ostensible design of our invention is to produce harmony; but even those who delight in *discord*, can find, in our instrument, a source of attraction. By putting down the modulation pedal belonging, for instance, to the scale of E, and playing in the scale of Ab, they will be furnished with an amount of discord, to which our common tempered instruments bear but a faint approximation. To express the effect, the ordinary term of "wolf" is weak. If this effect be too severe, any less amount of discord, or *temperament*, can be obtained by putting down a less remote modulation pedal. Discords have their appropriate place in music, but their place is *not* in a common chord, or where the composer designed a concord. In such combinations many love *pure* HARMONY, and we are among that number; this can be obtained by putting down the modulation pedal belonging to the scale in which the music is written.

50. As reference has been made to the organ of the Rev. Henry Liston, and also to errors (as we consider them,) in his plan, we will now, as we promised in the early part of this paper, speak of his plan, and show also, in what particulars the two instruments resemble each other. They both had for their object PERFECT TUNE. Both Mr. Liston and ourselves investigated, independently, and *ab integro*, the phenomena of music, to ascertain what sounds were necessary to a requisite number of perfect musical scales. We necessarily arrived at many and the same truths; in several respects also we differed; indeed, our plan was perfected, and the instrument partly completed, before we saw Mr. Liston's Essay.* When we come to the mechanism for carrying into operation our separate plans, all resemblance ceases. In the theory of the two instruments, the great difference is found in the *perfect seventh*, 4 : 7, in the chord of the seventh, for which Mr. Liston made no provision, but used, in its place, the fourth of the scale, 9 : 16. This combination is very discordant, and, when the *ninth* is added, (17.) is so harsh, that in Mr. Liston's opinion, the ninth ought not to be used with the seventh in this manner. Again, he has the major and minor keys of the same letter—as C major and C minor—founded upon the *same key-note* (27.); and he makes the major third of C the key-note of *four sharps*, &c.—thus destroying the *series of perfect fifths* by which the keys should be connected together. In the mechanism

* We take this opportunity to express our acknowledgment to Dr. Edward Hodges, Musical Director of Trinity Church, New York, for his kindness in voluntarily forwarding to us Mr. Liston's Essay, which is very rare; as it was published by subscription, and only a few copies were printed. We would moreover express to Dr. Hodges, and also to Prof. E. T. Fitch, of Yale College, our thanks for their sympathy and encouragement, when our plans had not so many friends as at present.

there is scarcely a point of resemblance, either in its internal structure or its management by the player. We cannot be expected here to give a description of our machinery, further than is necessary to understand the method of playing it, as it would require drawings to make it intelligible; and besides, we have already, we fear, exhausted the patience of our readers. On our organ, a single pedal will bring on an entire scale, extending through every set of pipes in the instrument, and the operation of the pedals is the same in every key. On Mr. Liston's organ, different keys required different combinations of pedals, with different degrees of difficulty. All the notes of some diatonic scales could not be brought on together by any combination of pedals, as for instance, in the scale of G, the organist could not obtain its second, A^3, and its sixth, E^3, at the same time; for when A^3 was brought on, E^3 always came with it, and A^2 always accompanied E^3.

51. The practicability, therefore, of building an organ which will give its chords in perfect tune, and can be easily managed for all music that is proper for the services of the church, is no longer a matter of speculation and doubt. The organ we have spoken of, has been in constant use for nine months, and has kept in perfect order. Good singers, whose ears have not been accustomed to a tempered accompaniment, agree with it perfectly, giving readily and naturally, all the intervals necessary to Perfect Intonation. Those who have been accustomed to sing with a common organ, require some practice before they have corrected their old habits, they are then prepared to appreciate the distinction between the pure harmony of nature and the discordant harmony of art.

52. Although we have not intended the organ for any music except such as *can be sung*, yet, if any one should write music very difficult, on account of its abrupt transitions from key to key, as for instance, from the key of C to four sharps, thence, straightway into four flats, &c., the music nevertheless can be played if the organist understands it. But probably no singers could sing such a composition without a guide, and any such music, (if any such there be) which cannot be played on the euharmonic organ, is certainly very far beyond the ability of singers to sing. In such music as a leader of good taste would select, the small addition to the duties of the organist is not sufficient to embarrass one of ordinary musical knowledge and skill, and for this extra care he will be richly repaid by the improvement in the harmony. Those who have *felt* the effect of perfect harmony, in the music of a quartette of natural and well drilled singers or violin-players, can form an idea of the harmony of the organ when in perfect tune. In training singers in correct intonation, this organ affords an aid which is invaluable; and to violin-players, it affords a certain guide for stopping their notes in tune.

53. We should not be treating the whole subject, if we did not speak of the relative *expense* of building the euharmonic organ. It can truly be said to be *more expensive*, at the same time, *more economical*, than the common organ. The extra machinery and pipes in this organ render it *more expensive;* its effect, and the musical satisfaction (which is the sole object of the organ, or any musical instrument) derived at a given outlay of money, renders it the *more economical.* The euharmonic organ of a given size and expense, would not contain as many sets of pipes or "stops," as each stop contains more pipes than the common organ, yet each set or *stop* is more effective, in power, than the same stop would be if tempered; for it is well known that musical sounds, which are in harmony, assist and strengthen each other, while discordant sounds neutralize and destroy each other. Besides, a great quantity of *mere sound* will no more afford musical pleasure, than mere painted canvas will satisfy the lover of painting. Church committees, who purchase organs, are not aware (as we organ-builders *could* inform them) that much which they pay for, is *mere trickery and trumpery.* There is, however, a desire, *in* the church, as well as *out* of it, to boast of an organ having as large a number of stops as possible, even if many of these furniture and reed stops, (having foreign names, which they do not understand,) are as inappropriate for the legitimate purposes of church music as a set of Chinese gongs. So long, however, as such a rivalry exists, and such instruments are ordered and paid for, they will be built; for this is the business of organ-builders. It is probable that any one who loves music at all, would prefer the music of a quartette of good singers, to a noisy chorus of fifty, singing no nearer in tune than the tempered organs play. As has been before stated, the theory of the instrument admits it to be of any size and power—the expense to be appropriated, must alone decide that point. This, however, can be stated with certainty, that a euharmonic organ in *perfect tune* and of sufficient size and power to perform satisfactorily the purposes of an organ in church, can be built for the expense which is usually appropriated to the larger class of instruments of *imperfect tune.*

54. Until it had been shown to be practicable by experiment, it was to be expected that a conservative portion of the public would view, with caution, a plan like the present, which proposes such a radical reformation in a system of so long standing as the organ scale. This feeling certainly operated against the plan when we proposed to undertake it two years since. It is with no little gratification that, since the completion of the instrument, it has had the favorable and unanimous opinion of the musical people who have examined it, and the scientific principles on which it is built. We believe it is certain that public musical opinion,

will ere long, among other improvements in the music of our churches, demand that it be given in *pure harmony*, and in accordance with the fixed and demonstrable principles of music.

That music may be investigated with something of the same learning and research which is bestowed upon almost every other science, is an end much to be desired. It will be gratifying to the writer—even if some of his opinions are shown to be incorrect—if his labors in this department of science, shall have the effect of calling to this subject the attention of those who are better qualified to make further investigations, and who can lay them before the public in a more interesting manner.

Note.—In the music example in (18.) page 77, the second lower note in the base clef, should be B♭ instead of D; and the ♭ also should have been placed on the second, instead of the third line. We would here also state that this and several other music examples in this paper were intended as theoretical illustrations, rather than as examples for actual execution.

ART. XXIII.—*On the new American Mineral, Lancasterite;* by Prof. B. SILLIMAN, Jr.

AMONG the minerals associated with the Serpentine of Texas, Lancaster Co., Pennsylvania, received through the kindness of Mr. L. White Williams of Westchester, one has close resemblance to Brucite. On chemical examination it has proved to be a new hydrous carbonate of magnesia, for which I propose the name *Lancasterite*. The following are its characters:—

Foliated like Brucite, affording thin pearly laminæ, inelastic and somewhat flexible. Also small crystals, which appear to be monoclinic (?) with an eminent pearly diagonal cleavage, H = 2·5. G = 2·33 according to my determinations; 2·35, according to H. Erni. Translucent. According to two analyses by H. Erni, it contains,

	1.	2.	Mean.	Oxygen.	
Carbonic acid,	27·07	26·85	26·96	19·61	1
Magnesia,	50·01	50·72	50·36	19·79	1
Protoxyd of iron,	1·01	0·96	0·99	0·21	
Water,	21·60	21·47	21·53	19·14	1
	99·69	100·00			

This gives the formula $\dot{M}g\,\ddot{C} + \dot{M}g\,\dot{H}^2$ = carbonic acid 27·11, magnesia 50·78, water 22·11 = 100. In two other trials the $\dot{H}$ and $\ddot{C}$ together equaled 49·83 and 49·86 after 1½ days drying in the water bath. In a matrass the mineral yields much water.

Before the blowpipe it exfoliates and becomes a little yellowish or brownish, and gives the reaction of magnesia. Dissolves with effervescence in acids.

We observe that Hermann has made a new mineral—which he calls *Pennite*—of the white and greenish incrustation of carbonate of magnesia accompanying Emerald nickel at Texas, Pa., and which, as we have remarked, appears to graduate into the Emerald nickel. He finds for its composition, carbonic acid 44·54, lime 20·10, magnesia 27·02, nickel 1·25, protoxyd of manganese 0·40, alumina 0·15, water 5·84 = 100, giving the formula $3(\dot{M}g, \dot{C}a, \dot{N}i)\ddot{C} + \dot{H}$. H = 3·5. G. = 2·86.

We have not yet had opportunity for trials to ascertain how far the water is a constant ingredient.

Art. XXIV.—*Table of Atomic Weights.*

The recent investigations of science, while evincing the consummate skill of the Swedish chemist, are introducing changes from time to time in the Berzelian atomic weights. These changes are in part the result of *direct* experiment on the particular substances, and in part an *indirect* consequence of these new determinations;—a change of one element involving necessarily a change in those other elements which were determined by using that one in the data. The following table is here inserted as an exposition of the recent results, only a part of which have hitherto appeared in this Journal, and these at distant intervals. In order to render it useful and convenient to the chemist, there are added to it the more common oxyds and sulphurets, and also the oxygen or sulphur per-centage for these compounds.

Hydrogen is taken as a single instead of a double atom, as this appears to be becoming the accepted mode among chemists. In the same manner, chlorine, iodine, bromine, phosphorus, nitrogen, arsenic and antimony, are written as single atoms or equivalents, with double the Berzelian atomic weight.

The multiples of the atomic weights of many of the oxyds are also given, as they save time and trouble, besides rendering accuracy in calculations more certain.

Various authorities are annexed, and different determinations for many of the elements, in order to give the means of comparison and choice to such as would use them, and especially for comparison with the new determinations that may hereafter be made.

The number of elements as now recognized is sixty-two, forty-nine of which are metals. J. D. D.

Aluminium, Al,	170·9	
Alumina, $\dot{Al}$,	641·8	(O, 46·74)
2 $\dot{Al}$	1283·6	
3 $\dot{Al}$	1925·4	
4 $\dot{Al}$	2567·2	
5 $\dot{Al}$	3209·0	
6 $\dot{Al}$	3850·8	
Antimony (Stibium), Sb,	1612·9	
Sul. Antim., $Sb\,S^3$,	2212·9	(S, 27·12)
Argentum (Ag) see *Silver.*		
Arsenic, As,	937·50*	*Pelouze.*
Arsenic Acid, $\dot{As}$,	1437·5	(O, 34·78)
Sulphuret of A., $As\,S^3$,	1537·5	(S, 39·0)
Aurum (Au) see *Gold.*		
Baryum, Ba,	856·8†	
Baryta, $\dot{Ba}$,	956·8	(O, 10·45)
2 $\dot{Ba}$	1913·6	
3 $\dot{Ba}$	2870·4	
4 $\dot{Ba}$	3827·2	
Beryllium (Be) see *Glucinum.*		
Bismuth, Bi,	1330·4	
Oxyd of Bismuth, $\dot{Bi}$,	2960·8	(O, 10·13)
Boron, B,	136·2	
Boracic Acid, $\dot{B}$,	436·2	(O, 68·78)
Bromine, Br,	1000‡	
Cadmium, Cd,	696·8	
Calcium, Ca,	251·49§	*Berz.*
Lime, $\dot{Ca}$,	351·49	(O, 28·45)
2 $\dot{Ca}$	702·98	
3 $\dot{Ca}$	1054·47	
4 $\dot{Ca}$	1405·96	
5 $\dot{Ca}$	1757·45	
6 $\dot{Ca}$	2108·94	
Carbon, C.	75	*Dumas.*
Carbonic Acid, $\dot{C}$,	275	(O, 72·73)
2 $\dot{C}$	550	
3 $\dot{C}$	825	
4 $\dot{C}$	1100	
5 $\dot{C}$	1375	
6 $\dot{C}$	1650	
Cerium, Ce,	575‖	*Hermann.*
Protoxyd of C, $\dot{Ce}$,	675	(O, 14·82)
Peroxyd of Cerium, $\ddot{Ce}$,	1450	(O, 20·69)
Chlorine, Cl.	443·3	
Hydrochlor. Acid, HCl,	455·8	
Chromium, Cr,	328·4¶	*Berlin.*
Oxyd of Chrome, $\ddot{Cr}$,	956·8	(O, 31·35)
Chromic Acid, $\dot{Cr}$,	628·4	(O, 47·74)
Cobalt, Co,	368·65	
Oxyd of Cobalt, $\dot{Co}$,	468·65	(O, 21·34)
Columbium(Tantalum)Ta,	1148·4	
Columbic Acid, $\ddot{Ta}$,	2596·8	(O, 11·55)
Copper (Cuprum), Cu,	396.6	
Oxyd of Copper, $\dot{Cu}$,	893·2	(O, 11·2)
Oxyd of Copper, $\dot{Cu}$,	496·6	(O, 20·14)
Didymium, D,	620?	*Marignac.*
Erbium, Eb,		
Ferrum (Fe) see *Iron.*		
Fluorine, F,	237·5	*Louyet.*
Hydrofluoric Acid, FH,	250·0	(F, 95)
Glucinum (Beryllium), Be,	58·084**	*Awd.*
Glucina, Be,	158·084	(O,63·26)
Gold (Aurum), Au,	2455††	
Hydrargyrum (Hg) see *Quicksilver.*		
Hydrogen, H,	12·5‡‡	
Water, $\dot{H}$,	112·5	(O, 88·89)
2 $\dot{H}$	225·0	
3 $\dot{H}$	337·5	
4 $\dot{H}$	450·0	
5 $\dot{H}$	562·5	
6 $\dot{H}$	675·0	
7 $\dot{H}$	787·5	
8 $\dot{H}$	900·0	
9 $\dot{H}$	1012·5	
Iodine, I,	1586	
Iridium, Ir.	1232	
Iron (Ferrum), Fe,	350§§	
Protoxyd of Iron, $\dot{Fe}$,	450	(O, 22·22)
2 $\dot{Fe}$	900	
3 $\dot{Fe}$	1350	
4 $\dot{Fe}$	1800	
5 $\dot{Fe}$	2250	
6 $\dot{Fe}$	2700	
Peroxyd of Iron, $\ddot{Fe}$,	1000	(O, 30)
Kalium (K) see *Potassium.*		
Lanthanum, La,	588‖‖	*Marignac.*
Protoxyd of L., $\dot{La}$,	688	(O, 14·55)
Peroxyd of L., $\ddot{La}$.	1476	(O, 20·33)
Lead (Plumbum), Pb,	1294·6	
Oxyd of Lead, $\dot{Pb}$.	1394·6	(O, 7·17)

* 938·8, *Berzelius.*

† 854·85, *Berzelius,* taking chlorine at 443·20, and silver at 1349·01.—858·08, *Pelouze;* 856·77, *Marignac.*

‡ 999·98, *Marignac.*

§ 250, *Dumas,* and *Marchand and Erdmann.* This gives for $\dot{Ca}$ 350 (O, 28·57).

‖ 572·8, *Rammelsberg;* 576·97. *Beringer;* more recent, (1849), 590·8, *Marignac,* which gives for $\dot{Ce}$ 690·8 (O, 14·48), and for $\ddot{Ce}$, 1481·6 (O, 20·25).

¶ More recently 334, *Moberg,* which gives for $\ddot{Cr}$ 968 (O, 31); and for $\dot{Cr}$ 634 (O, 47·3).

** According to Kobell and Awdejew, glucina is a protoxyd. Yet some distinguished chemists still consider it a peroxyd, like alumina; making glucinum (Be) 331·26, and glucina ($\ddot{Be}$) 962·52 (O, 31·17); or Be 87·12 and $\ddot{Be}$ 474·24, *Berz.*

†† 1227·75, *Berz.,* corrected by Pelouze for the new atomic weight of quicksilver. *Pelouze* has recently obtained 1227·45. Most chemists now double this number as above.

‡‡ 12·48, *Berzelius.*

§§ 350·527, *Berzelius;* more recently, 349·8, *Svanberg* and *Norlin.*

‖‖ 554·88, *Rammelsberg;* 600, *Hermann;* 580, *Mosander.* The last is a mean of the different determinations, and gives for $\dot{La}$ 680 (O, 14·7), and for $\ddot{La}$ 1460 (O, 20·55).

Lime, see *Calcium.*		
Lithium, Li,	81·66	
Lithia, $\dot{L}i$,	181·66	(O, 55·05)
Magnesium, Mg,	154·5*	*Svanb.*
Magnesia, $\dot{M}g$,	254·5	(O, 39·3)
2 $\dot{M}g$	509·0	
3 $\dot{M}g$	763·5	
4 $\dot{M}g$	1018·0	
5 $\dot{M}g$	1272·5	
6 $\dot{M}g$	1527·0	
Manganese, Mn,	344·7	
Protoxyd of M., $\dot{M}n$,	444·7	(O, 22·47)
2 $\dot{M}n$	889·4	
3 $\dot{M}n$	1334·1	
4 $\dot{M}n$	1778·8	
Peroxyd of M., $\ddot{M}n$,	989·4	(O, 30·32)
2 $\ddot{M}n$	1978·8	
3 $\ddot{M}n$	2968·2	
4 $\ddot{M}n$	3957·6	
Mercury (Hg) see *Quicksilver.*		
Molybdenum, Mo,	575·83†	*Svanb.*
Molybdic Acid, $\ddot{M}o$.	875·83	(O, 34·3)
Natrium (Na) see *Sodium.*		
Nickel, Ni,	369·33	
Protoxyd of Nickel, $\dot{N}i$,	469·33	(O, 21·3)
Niobium, Nb,		
Nitrogen, N,	175·06	
Nitric Acid, $\ddot{N}$,	675·06	(O, 74)
2 $\ddot{N}$	1350·12	
3 $\ddot{N}$	2025·18	
4 $\ddot{N}$	2700·24	
Norium,		
Osmium, Os,	1242·6	
Oxygen, O,	100	
Palladium, Pd,	665·48	
Pelopium,		
Phosphorus, P,	392‡	*Berz.*
Phosphoric Acid, $\ddot{P}$,	892	(O, 56·05)
2 $\ddot{P}$	1784	
3 $\ddot{P}$	2676	
4 $\ddot{P}$	3568	
Platinum, Pt,	1232·08	
Plumbum (Pb) see *Lead.*		
Potassium (Kalium), K,	488·86§	
Potassa, $\dot{K}$,	588·86	(O, 16·98)
2 $\dot{K}$	1177·72	
3 $\dot{K}$	1766·58	
4 $\dot{K}$	2355·44	
Quicksilver (Hydrargyrum), Hg,	1250‖	
Rhodium,	651·96	
Ruthenium, Ru,	*undetermined.*	
Selenium, Se,	495·3¶	
Silicium, Si,	277·31**	*Berz.*
Silica, $\ddot{S}i$,	577·31	(O, 51·96)
2 $\ddot{S}i$	1154·62	
3 $\ddot{S}i$	1731·93	
4 $\ddot{S}i$	2309·24	
5 $\ddot{S}i$	2886·55	
6 $\ddot{S}i$	3463·86	
7 $\ddot{S}i$	4041·17	
8 $\ddot{S}i$	4618·48	
9 $\ddot{S}i$	5195·79	
Silver (Argentum), Ag,	1350††	
Sulphuret of S., AgS,	1550	(S, 12·9)
Sodium (Natrium), Na,	287·2‡‡	
Soda, $\dot{N}a$,	387·2	(O, 25·83)
2 $\dot{N}a$	774·4	
3 $\dot{N}a$	1161·6	
4 $\dot{N}a$	1548·8	
Stannum (Sn) see *Tin,*		
Stibium, (Sb) see *Antimony.*		
Strontium, Sr,	548§§	*Pelouze.*
Strontia, $\dot{S}r$,	648	(O, 15·43)
Sulphur, S,	200‖‖	
Sulphuric acid, $\ddot{S}$,	500	(O, 60)
Tantalum (Ta) see *Columbium.*		
Tellurium, Te,	801·8	
Terbium, Tb,		
Thorium, Th,	743·86	
Thoria, $\dot{T}h$,	843·9	(O, 11·84)
Tin, (Stannum), Sn,	735·3¶¶	
Oxyd of Tin, $\dot{S}n$,	935·3	(O, 21·38)
Titanium, Ti,	314·7***	
Oxyd of Titanium, $\ddot{T}i$,	929·4	(O, 32·28)
Titanic Acid, $\ddot{T}i$,	514·7	(O, 38·86)
Tungsten (Wolframium) W,	1188·4	
Tungstic Acid, $\ddot{\ddot{W}}$,	1488·4	(O, 20·16)
Uranium, U,	750†††	*Peligot.*
Protoxyd of U., $\dot{U}$,	850	(O, 11·76)
Peroxyd of U., $\ddot{U}$,	1800	(O, 16·66)
Protoperox. of U., $\dot{U}\ddot{U}$,	2650	(O, 15·10)
Vanadium, V,	856·9	
Water, see *Hydrogen.*		
Wolframium (W) see *Tungsten.*		
Yttrium, Y,	402·5	
Yttria, $\dot{Y}$,	502·5	(O, 19·90)
Zinc, Zn,	406·6	*Erdmann.*
Oxyd of Zinc, $\dot{Z}n$,	506·6	(O, 19·74)
Zirconium, Zr,	419·73	
Zirconia, $\dot{Z}r$,	1139·5	(O, 26·3)

* 158·14, *Berzelius;* 151·33, *Scheerer.*

† 596·1, *Berzelius,* revised.

‡ 400·10, *Pelouze.*

§ 488·856, *Berzelius;* 487·004, *Maumené.*

‖ 1247·33, 1248·21, 1249·27, *Svanberg;* 1250·6, *Erdmann and Marchand;* 1250, (nearly a mean of these determinations), *Millon;* 1251·29, *Berz.*

¶ 491, Sacc.

** 266·742, *Pelouze,* more recent; 277·778, *Berzelius* revised.

†† 1349·66, *Berzelius;* 1349·01, *Marignac;* 1350·32, *Maumené.*

‡‡ 287·17, *Pelouze;* 390·9, and later revision, 289·73, *Berzelius.*

§§ 545·93, *Berz.*

‖‖ 200·75, *Berzelius,* making sulphuric acid 500·75 (O, 59·91); 200·02, *Erdmann and Marchand,* considering 1250·6, the equivalent for quicksilver.

¶¶ Recently, 725, *Mulder.*

*** 301·55, *Berzelius;* 303·3, *H. Rose;* 295·8, *Mosander;* 314·69, *Pierre.*

††† 746·34, *Wertheim;* the earlier results give 2711·4, making $\ddot{U}$=5722·72 (O, 5·24).

Art. XXV.—*On the Isomorphism and Atomic Volume of some Minerals;* by James D. Dana.*

Having perused recent statements by Prof. G. Rose respecting some anomalous cases of isomorphism, and also having remarked that the chemically unlike minerals chrysoberyl and chrysolite were essentially alike in form, I was led to a farther search for such singular anomalies among minerals in order to elicit the principle upon which they depend. The results of the investigation have proved interesting beyond what was expected, and are detailed in the following pages.

Before proceeding with them, the facts observed by Prof. Rose should be mentioned. He points out the relations of bismuth, arsenic and some other metals,† and also shows that specular iron and alumina are isomorphous with them, as seen in the following table.

Osmium,	R : R=84°52′	Bismuth,	R : R=87°40′
Iridium,	84 52	Palladium,	undetermined.
Arsenic,	85 04		
Tellurium,	86 57	Corundum (alumina) Ȧl	R : R=86 4
Antimony,	87 35	Specular iron (Ḟe)	85 58
		Titanic iron (Ḟe, Ṫi)	85 59

Prof. Rose also gives the following parallel groups of isomorphs.‡

1. *Form that of Calc Spar.*

			R : R
a.	Calc spar and isomorphs	R̈C̄	105° – 107°40′
b.	Nitrate of soda	N̈aN̄	106 33
c.	Dark red silver ore	3AgS+SbS³	108 18
	Light red silver ore	3AgS+AsS³	107 36

2. *Form that of Arragonite (dimorph with the preceding).*

			M : M
a.	Arragonite, white lead ore, &c.	R̈C̄	116° – 118°30′
b.	Nitrate of potash	K̇N̄	119
c.	Bournonite	3(Cu, Pb)S+SbS³	115 16

Many examples of this kind of isomorphism have come to light in the course of the research; and moreover an explanation is at hand in *the relations of atomic volume*—the same principle appealed to by Kopp for explaining the cases of ordinary isomorphism.

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* The atomic numbers adopted in the body of the preceding table have in a few instances been slightly changed, since this article was printed: in such cases, the numbers employed in the following pages will be found in the notes to the table.

† On the rhombohedral metals. Monatsb. der Königl. Preuss. Akad. der Wissenschaften zu Berlin, April, 1849, p. 137.

‡ In an article "on a remarkable analogy of form between certain sulphur and oxygen salts," Monatsbericht der Königl. Preuss. Akad. d. Wissenschaften zu Berlin, Jan., 1849, p. 13. Pogg. Annal., lxxvi, p. 291.

Rammelsberg endeavored to apply this principle in accounting for the relations of epidote and different varieties of orthite.* As is customary in such investigations, he determined the atomic volume of the compounds and compared the ascertained numbers with one another. But the relation obtained was not sufficiently simple to be wholly satisfactory. One additional step seems to throw farther light on the subject, and leads to general conclusions not otherwise apparent. This step consists simply in *dividing the aggregate atomic volume of the compound by the number of atoms of the elements present.* Unlike compounds are thus reduced to a single standard. The correctness of such a step is proved by the general correspondence obtained between likeness of form and volume. The relations between the *aggregate* atomic volume of isomorphous compounds is in many cases necessarily complex; for we find that this relation is expressed most nearly by the proportional number of molecules of elements in those compounds. Between ryacolite and loxoclase, for example, this relation is that of 15 : 19, and between labradorite and anorthite, that of 15 : 37 (see page 233).

That the subject may be fully illustrated and the facts on all sides fairly exhibited, I have in the following pages given with equal detail, (A) the aggregate atomic volume; (B) this aggregate atomic volume divided by the number of atoms of acids and bases; and (C) the same divided by the number of atoms of the elements. The peculiar interest of each of these modes of viewing the atomic volume will thus be clearly shown: and while not underrating the ratios ascertained by the *first*, we think that an additional value will be found in the relations developed by the *third* method; and also that some importance may attach to the *second*. In some cases the (B) relation is singularly close and of interest. The atomic volumes of alumina and arsenic are almost identical (161·7 and 163); while if we divided by 5, the number of atoms in alumina, it gives, instead of a ratio of equality, the ratio of 1 : 5. These modes of viewing the subject of atomic volume appear to open the way for important conclusions bearing upon some of the most recondite points in chemical science.

Hermann has written at considerable length upon isomorphism among compounds of unlike atomic constitution.† He has confined himself almost exclusively to pointing out such well known cases as the chemically unlike varieties of epidote, scapolite, etc., (which the crystallographer has often united and the chemist as often pulled asunder)—besides some acknowledged instances of isomorphism. He has introduced for such cases the new term *heteromerism*, a term of indefinite signification, since all com-

* Poggendorff's Annalen, 1849, No. 1, lxxvi, p. 80.

† Erdmann und Marchand's Journal für Praktischen Chemie, xliii, 35.

pounds of *unlike* atomic proportions are heteromerous, whether isomorphous or not.

Without farther introduction I proceed with the details of the observations—mentioning, first, some of the prominent cases of isomorphism among unlike compounds; and then giving the researches into the atomic volume of these and other species.

I. CHRYSOBERYL, $\dot{B}e\ddot{A}l$—CHRYSOLITE, $(\dot{M}g\ \dot{F}e)^3\ \ddot{S}i$—SERPENTINE, $2\dot{M}g^3\ \ddot{S}i^2+3\dot{M}g\ \dot{H}^2$—EPSOM SALT, $\dot{M}g\ \ddot{S}+7\dot{H}$—VILLARSITE, $4(\dot{F}e, \dot{M}g)^3\ \ddot{S}i+3\dot{H}$—PICROSMINE, $2\dot{M}g^3\ \ddot{S}i^2+3\dot{H}$.

The magnesian minerals, Chrysolite, Serpentine and Villarsite, are well known to be isomorphous, and have been the subject of recent remarks by Hermann.* We now add the totally unlike minerals, Chrysoberyl and Epsom salt.

A brachydiagonal prism in Chrysolite has the angle 80° 53′, a corresponding one in Chrysoberyl 119° 46′. The tangents of half these angles are nearly as 1 : 2; and a vertical prism of the former has the angle 49° 50′ and one of Chrysoberyl 70° 40′, giving the relation of 1 : 1½. The former planes, referred to the same fundamental form, are respectively $\breve{P}\infty$ and $2\breve{P}\infty$, and the latter ∞P and $\infty P\frac{3}{2}$. The crystallographic axes of these species as given by von Kobell are as follows:—

	a.		*b.*		*c.*
Chrysoberyl,	0·58	:	1	:	0·47
Chrysolite,	1·1733	:	1	:	0·93

The ·93 of Chrysolite it is seen is double of ·47 in Chrysoberyl, and 1·1733 is double of 0·58 showing a simple ratio. If we take for Chrysolite the vertical prism above alluded to (49° 50′) as the prism ∞P, it gives $b:c=1:0{\cdot}465$, which is almost identical with that for chrysoberyl. We add farther, though other evidence is unnecessary, that the angles of the corresponding rhombic octahedrons in each of the above species, are given as follows:—

Chrysolite,	139°55′	85°15′	108°31′
Serpentine,	139 34	88 26	105 26
Villarsite,	139 45	86 56	106 52
Chrysoberyl,	139 53	86 16	

In Picrosmine, a brachydiagonal prism has the angle 117°49′, which is near that of Chrysoberyl, and a vertical prism the angle 53° 08′, the corresponding angle in Chrysolite being 49° 50′. This prism being the prism ∞P, it gives $b:c=1:0{\cdot}5$, while it is 1 : 0·47 in Chrysoberyl, and 1 : 0·465 in Chrysolite.

Epsom salt has the same axes as Chrysolite, except that for the assumed fundamental form,† the vertical axis is about one-half the

* J. f. Pr. Chem., 1849, xlvi, 229.

† It may not be understood by all my readers that the axes of crystals are not lines of fixed length for each crystal, but only the axes corresponding to a form or set of planes in the crystal *assumed* as the fundamental form—a form of frequent

above in length. The numbers given are 0·5703 : 1 : 0·9089, which on doubling the first term becomes 1·1406 : 1 : 0·9089.

II. QUARTZ, $\ddot{S}i$—CHABAZITE, $(\dot{C}a, \dot{N}a, \dot{K})^3\ddot{S}i^2+3\ddot{A}l\,\ddot{S}i^2+18\dot{H}$.

R : R in Quartz = 94° 15′; in Chabazite = 94° 46′.

III. CORUNDUM, $\ddot{A}l$—PHENACITE, $\dot{B}e^3\,\ddot{S}i$, together with *Arsenic* and others of the group on page 220.

Taking the angle of the rhombohedron of phenacite at 115° 25′, the axis $a = 0{\cdot}6958$. The axis a of Corundum = 1·3617, which is nearly double that of phenacite ($2 \times 0{\cdot}6958 = 1{\cdot}3916$). The angle of the rhombohedron 2R of phenacite is 83° 12′; while R : R in corundum is 86° 4′; in Iridium 84° 52′; in Arsenic 85° 04′.

IV. SCHEELITE, $\dot{C}a\,\dddot{W}$—(with TUNGSTATE OF LEAD, $\dot{P}b\,\dddot{W}$ and MOLYBDATE OF LEAD, $\dot{P}b\,\ddot{M}o$)=FERGUSONITE, $\dot{Y}^6\,\ddot{T}a$.

Tungstate of lime and Fergusonite crystallize in square octahedrons which are hemihedrally modified in the same manner. In the former the angle of the octahedron is 100° 8′; in the latter a corresponding octahedron has the pyramidal angle 100° 28′. The axis of Tungsten is given at 1·05, and that of Fergusonite, (another pyramid being assumed as fundamental,) at 1·50; the latter is 1½ times the former—a simple relation. Tungstate of lead, a recognized pseudomorph of Tungsten, has A : A = 99° 43′, and Molybdate of lead, also so recognized, has A : A = 99° 40′.

We also observe that the vertical axis of *Idocrase* is about half that of Tungstate of lime.

V. ZIRCON, $\ddot{Z}r\,\ddot{S}i$—RUTILE, $\ddot{T}i$—TIN ORE, $\ddot{S}n$.

Rutile and Tin ore are recognized isomorphs; the basal angle of the octahedral fundamental forms are 84° 40′ for the former and 87° 5′ for the latter. In Zircon, the same angle is 84° 20′. The axes of rutile, tin ore and zircon are respectively 0·655, 0·6743, 0·6405.

VI. CINNABAR, Hg S—EUDIALYTE, $2\dot{R}^3\,\ddot{S}i^2+\ddot{Z}r\,\ddot{S}i^2$.

Cinnabar and Eudialyte are rhombohedral. In the former R : R = 71° 47′; in the latter, = 73° 40′.

VII. BORAX, $\dot{N}a\,\ddot{B}^2+10\dot{H}$—PYROXENE, $\dot{R}^3\,\ddot{S}i^2$—GLAUBER SALT, $(\dot{N}a\,\ddot{S}+10\dot{H})$.

In Pyroxene	M : M = 87°6′;	0P : ∝P∝ = 106°6′	axes	0·2867 : 1 : 0·9506
In Borax	" 87°	" 106°35′		0·2978 : 1 : 0·9489

Glauber salt is also near pyroxene. It has M : M = 86° 31′ and 0P : ∝ P ∝ = 104° 41′.

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occurrence being selected. They express only a relation of length, and constitute a measure for determining or designating all the other occurring forms. The form assumed for Epsom salt, would be the form ½P of Chrysolite. And if the planes ½P in Epsom salt were taken for the fundamental form then the axes would be the same (nearly) as for Chrysolite.

VIII. ANATASE, $\dot{T}i$—HORN QUICKSILVER, $Hg\,\dot{C}l$.

A pyramid in Horn quicksilver has the basal angle 136°; and the corresponding angle of anatase is 136° 22′.

IX. SULPHUR, S, and SCORODITE, $\dot{F}e\,\ddot{A}s+4\dot{H}$.

The axes of sulphur are 1·9043 : 1 : 0·8108; and those of Scorodite 0·9539 : 1 : 0·8527. The vertical axis of sulphur is hence double that of Scorodite ($2\times0{\cdot}9539=1{\cdot}9078$), while the other axes are nearly equal. (The planes of the vertical rhombic prism common on crystals of scorodite, belong to the form $\infty\breve{P}2$.)

X. CELESTINE, $\dot{S}r\,\ddot{S}$—WHITE IRON PYRITES, $Fe\,S^2$—GRAPHIC TELLURIUM, $Ag\,Te+2Au\,Te^3$.

The angle M : M of Celestine is 104°; of White Iron Pyrites 106° 2′; a brachydiagonal prism of the former has the side angle 103° 58′; of the latter 99° 58′. Graphic Tellurium has M : M = 107° 44′; a macrodiagonal prism in Celestine is 101° 24′, in Graphic Tellurium 103°.

XI. CHROMATE OF LEAD, $\dot{P}b\,\ddot{C}r$—MONAZITE, $(\dot{C}e, \dot{T}h, \dot{L}a)^3\,\ddot{P}$.

The forms are monoclinic. In Chromate of Lead, M : M = 93° 40′ and P : M = 99° 11′. In Monazite, M : M = 93° 10′ and P : M = 100° – 100° 25′. The forms of the crystals are similar in the occurring secondary planes.—Compare figure 2 of Chromate of Lead in the author's Mineralogy* with 2 of Monazite in the same work;† the general form is similar; and the planes M, $\breve{e}$, $\breve{e}$, $\breve{a}$, $\breve{c}$, a, a', ($\infty P, +P, -P, -P\infty, \infty P'\infty, P'\infty, 2P'\infty$) are the same in the two. $\breve{e}:\breve{e}$ in the former is 119°, in the latter 119° 22′; $\breve{e}:\breve{e}$ in the former is 107° 40′, in the latter 106° 36′.

XII. BERYL, $\dot{B}e\,\ddot{S}i^4+2\dot{A}l\,\ddot{S}i^2$, or $\dot{B}e^3\,\ddot{S}i^2+\dot{A}l\,\ddot{S}i^2$—NEPHELINE, $\dot{R}^2\,\ddot{S}i+2\dot{A}l\,\ddot{S}i$.

In Nepheline, P on two planes on the basal edges is 134° 3′ and 154° 27′; in beryl, the corresponding angles are 130° 59′ and 150° 6′. The vertical axis of nepheline is 0·4629, of beryl 0·4993. These species are only approximately isomorphous.

The axis of *quartz* is a little more than double that of beryl, it being 1·0996 and $2\times0{\cdot}4993=0{\cdot}9996$.

We mention also, without particular remark, some of the admitted cases of isomorphism, among species that are alike in general constitution but different in atomic proportions.

1. Pyroxene, Acmite, Hornblende and varieties.
2. Scapolite, Meionite, Wernerite, Dipyre, Gehlenite.
3. Talc, containing magnesia and silica in different proportions.

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* Fig. 74, pl. x, Mohs's Naturg. des Min., ii.

† Also Am. Jour. Sci., xxxiii, p. 71, fig. 1, but with different lettering; and the same figure copied in Dufrenoy's Mineralogie, vol. iv, pl. 223, fig. 476.

4. Epidote, Zoisite, Orthite.
5. The Feldspar family.
6. Bucholzite, Kyanite.
7. Different groups among the monometric or tesseral species.

It is not my object in this place to mention the cases of isomorphism that conform to the ordinary law on this subject. With this brief enumeration of some of the groups, I proceed to the consideration of the atomic volumes of the species. The atomic volume is obtained by dividing the atomic weight by the specific gravity.

I present first an example of the atomic volumes of a group of acknowledged isomorphous minerals, as a measure of the degree of discrepancy to be expected. The carbonates of lime, lime and magnesia, manganese, iron, magnesia, and zinc, increase in the angle R : R from 105° 5′ to 107° 40′, and the atomic volumes, as determined by Kopp, are respectively as follows:

231·20, 202·36, 202·29, 188·50, 181·25, 175·33.

The range of numbers is quite wide in this series, amounting to ¼ the larger number, and exceeds what usually occurs among isomorphous species. Yet the extent of the variation, here shown to be possible, should be kept in mind, or we may be led into error by expecting too close coincidences.

In the following calculations, either the mean specific gravity, as nearly as it could be determined, has been taken, or the specific gravity corresponding to some analysis selected for comparison. The atomic weights used are from the table on pages 218, 219, of this volume. By way of distinction as well as brevity in the following enunciations, we number the statement of the aggregate atomic volume by A; that in which the aggregate atomic volume is divided by the number of atoms of bases and acid, by B; and that of the same divided by the number of atoms of the elements, by C.

I. *Chrysoberyl, Chrysolite, Serpentine, Villarsite, Picrosmine, Epsom Salt.*

1. Chrysoberyl.

1 $\dot{B}e$=158·084 *b.* atoms of acid and base, 2. *c.* atoms of elements, 7.
1 $\ddot{A}l$ 641·80 A. 799·884÷3·7 (sp. gr.)=216·18

a. At. weight, 799·884 B. 216·18÷2=108·9 C. 216·18÷7=30·9

With the old atomic weight of Glucinum, making glucina 962·52, we have the formula $\dot{B}e\,\ddot{A}l^6$, which gives

1 $\dot{B}e$ 962·52 *b.* atoms of acid and base, 7. *c.* atoms of elements, 35.
6 $\ddot{A}l$ 3850·8 A. 4813·32÷3·7 (sp. gr.)=1300·9

a. At. volume, 4813·32 B. 1300·9÷7=185·8 C. 1300·9÷35=37·16

The formula $\ddot{A}l^4\,\ddot{S}i+2\dot{B}e\,\ddot{A}l^4$, which differs from the last only in including an atom of silica for 12 of alumina, gives the value of C equal to 37·29.

With von Kobell's atomic weight, which is for glucina one third the last mentioned, (320·98 for glucina), chrysoberyl is $\dot{B}e\,\ddot{A}l^2$, and the atomic weight is 1604·58; A=433·7; B=144·6; C=56·14.

2. Chrysolite.

1	$\ddot{S}i$=577·31	*b.* atoms of acid and bases, 4.	*c.* atoms of elements, 10.
$2\frac{II}{II}$	Mg 694·1	A. 1394·13÷3·35 (sp. gr.)=416	
$\frac{I}{II}$	Fe 122·72	B. 416÷4=104	C. 416÷10=41·6

a. At. weight, 1394·13

3. Serpentine.

4	$\ddot{S}i$= 2309·24	*b.* atoms of acid and bases, 19.	*c.* atoms of elements, 46.
9	Mg 2290·50	A. 5274·62÷2·55 (sp. gr.)=2068·5	
6	H 674·88	B. 2068·5÷19=109	C. 2068·5÷46=44·9

a. At. weight, 5274·62

4. Villarsite.

4	$\ddot{S}i$= 2309·24	*b.* atoms of acid and bases, 19.	*c.* atoms of elements, 46.
12	Mg 3054·0	A. 5700·68÷2·975 (sp. gr.)=1916·3	
3	H 337·44	B. 1916·3÷19=100·86	C. 1916·3÷46=41·65

a. At. weight, 5700·68

5. Picrosmine.

4	$\ddot{S}i$= 2309·24	*b.* atoms of acid and bases, 13.	*c.* atoms of elements, 34.
6	Mg 1527·0	A. 4173·68÷2·63 (sp. gr.)=1587	
3	H 337·44	B. 1587÷13=122	C. 1587÷34=46·68

a. At. weight, 4173·68

6. Epsom Salt.

1	$\ddot{S}$= 500·	*b.* atoms of acid and bases, 9.	*c.* atoms of elements, 20.
1	Mg 254·5	A. 1541·86÷1·75 (sp. gr.)=881	
7	H 787·36	B. 881÷9=98	C. 881÷20=44

a. At. weight, 1541·86

The result shows that these different substances have for atomic volume C, Chrysolite 41·6, Villarsite 41·65, Epsom salt 44, Serpentine 44·9, Picrosmine 46·7; and for Chrysoberyl 30·9, (adopting Awdejew's atomic weight,) which is to that of Chrysolite as 2 : 3; or with the old atomic weight 37·15, a little below that of Chrysolite. The B results are also nearly uniform; they are for Chrysolite 104, for Villarsite 100·86, Epsom salt 98, Serpentine 109, Picrosmine 122, Chrysoberyl 108·9, or with the old atomic weight, 185·77. It would seem from the result with Epsom salt, that it is more correct to consider the hydrogen in water as a single rather than a double atom.

We pass on with the other examples without special remark, the results being tabulated on a subsequent page.

II. *Quartz, Chabazite.*

1. Quartz.

$\ddot{S}i$= 577·31 A. 577·31÷2·65 (sp. gr.)=218. C. 218÷4=54·5.

2. Chabazite.

8	$\ddot{S}i$=4618·48	*b.* atoms of acid and bases, 32.	*c.* atoms of elements, 89.
3	$\ddot{A}l$ 1925·4	A. 9622·99÷2·1 (sp. gr.)=4582·4	
3	$\dot{C}a$ 1054·47	B. 4582·4÷32=143.	C. 4582·4÷89=51·5
18	H 2024·64		

a. At. weight, 9622·99

III. *Corundum, Specular Iron, Arsenic, Phenacite.*

1. Corundum. $\dot{\overline{Al}}$=641·8÷3·97 (sp. gr.)=161·7 C. 161·7÷5=32·3
2. Specular Iron. $\dot{Fe}$=1000÷5·212 (sp. gr.)=192 C. 192÷5=38·4
3. Arsenic. As, 940·08÷5·75 (sp. gr.)=163, which equals 5×32·6. The specific gravity 5·88 gives for atomic volume 160.
4. Phenacite.

1 $\overline{Si}$=	577·31	*b.* atoms of acid and base, 4. *c.* atoms of elements, 10.
3 $\dot{Be}$	474·25	A. 1051·56÷2·97 (sp. gr.)=354
a. At. weight,	1051·56	B. 354÷4=88·5 C. 354÷10=35·4

With the old atomic weight for glucinum, Phenacite has the formula $\dot{Be}\,\overline{Si}^2$, which gives

A. 2117·14÷2·97 (sp. gr.)=713 C. 713÷13=55, which is 1½ times that of specular iron.

Antimony, Bismuth, Tellurium and Osmium are isomorphous with Arsenic.

5. Antimony, Sb, 1612·8÷6·702 (sp. gr.)=240·65
6. Bismuth, Bi, 1330·4÷9·8 (sp. gr.)=135·75
7. Tellurium, Te, 802÷6·2 (sp. gr.)=129·36
8. Osmium, Os, 1242·6÷10 (sp. gr.)=124·26

The atomic volume of Corundum is to that of Arsenic as 1 : 5, to that of Antimony nearly as 1 : 8, and to that of each of the other metals following nearly as 1 : 4. The discrepancies, if considered such, it will be observed are among *acknowledged isomorphs;* and a more exact knowledge of the atomic weight may remove them.

IV. *Scheelite, Tungstate of Lead, Fergusonite.*

1. Scheelite.

1 $\dddot{W}$ =	1488·4	*b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
1 $\dot{Ca}$	351·5	A. 1839·9÷6·1 (sp. gr.)=301·6
a. At. weight,	1839·9	B. 301·6÷2=150·8 C. 301·6÷6=50·3

2. Tungstate of Lead.

1 $\dddot{W}$ =	1488·4	A. 2882·9÷8·1 (sp. gr.)=355·9
1 $\dot{Pb}$	1394·5	B. 355·9÷2=177·9 C. 355·9÷6=59·3
a. At. weight,	2882·9	

3. Fergusonite. *b.* atoms of acid and base, 7. *c.* atoms of elements, 7.

1 $\dot{Ta}$	2596·8	A. 5611·8÷5·8 (sp. gr.)=967·5.
6 $\dot{Y}$	3015·0	B. 967·5÷7=138·2 C. 967·5÷17=57·0.
a. At. weight,	5611·8	

We have introduced here the acknowledged isomorph of Scheelite, Tungstate of Lead, in order to afford a more satisfactory comparison with Fergusonite.

V. *Zircon, Rutile, Tin Ore* (acknowledged isomorph of rutile).

1. Zircon.

1 $\overline{Si}$ =	577·31	*b.* atoms of acid and base, 2. *c.* atoms of elements, 9.
1 $\dot{Zr}$	1139·50	A. 1716·81÷4·636 (sp. gr.)=370·3
a. At. weight,	1716·81	B. 370·3÷2=185·15 C. 370·3÷9=41·15.

2. Rutile. $\dot{Ti}$=514·7÷4·21 (sp. gr.)=122·3. C. 122·3÷3=40·7
3. Tin Ore. $\dot{Sn}$=935·3÷6·96 (sp. gr.)=134·4. C. 134·4÷3=44·8

VI. *Cinnabar, Eudialyte.*

1. Cinnabar. Hg S—1450 1450÷8·1 (sp. gr.) —180. C. 180÷2—90.

2. Eudialyte.

6 $\overline{Si}$	3463·86	*b.* atoms of acid and bases, 13.	*c.* atoms of elements, 41.
1 $\overline{Zr}$	1139·50	A. 6909·33÷2·9 (sp. gr.) —2382	
1 $\dot{Fe}$	450·00	B. 2382÷13—183·2	C. 2382÷41—58·1
2½ $\dot{Ca}$	878·72		
2½ $\dot{Na}$	977·25		

a. At. weight, 6909·33

The relation of 58 : 90, is nearly as 2 : 3 (60 : 90.); of 180 : 183·2=1 : 1

VII. *Borax, Glauber Salt, Pyroxene.*

1. Borax.

2 $\overline{B}$ —	872·4	*b.* atoms of acid and bases, 13.	*c.* atoms of elements, 30.
1 $\dot{Na}$	390·9	A. 2388·1÷1·716—1391·6	
10 $\dot{H}$	1124·8	B. 1391·6÷13=107·0	C. 1391·6÷30—46·38.
a. At. weight,	2388·1		

2. Glauber Salt.

1 $\overline{S}$ —	500·	*b.* atoms of acid and bases, 12.	*c.* atoms of elements, 26.
1 $\dot{Na}$	390·9	A. 2015·7÷1·562 (sp. gr.) —1290·5.	
10 $\dot{H}$	1124·8	B. 1290·5÷12—107·54	C. 1290·5÷26—49·6
a. At. weight,	2015·7		

3. Pyroxene.—1st. var. $(\frac{1}{2}\dot{Ca}+\frac{1}{2}\dot{Mg})^3\,\overline{Si}^2$. Color white.

2 $\overline{Si}$	—1154·62	*b.* atoms of acid and bases, 5.	*c.* atoms of elements, 14.
1½ $\dot{Ca}$	527·23	A. 2063·60÷3·24 (sp. gr.) —637	
1½ $\dot{Mg}$	381·75	B. 637÷5—127·4	C. 637÷14—45·5
a. At. weight,	2063·60		

4. Pyroxene.—2nd. var. $(\frac{1}{2}\dot{Ca}+\frac{1}{2}\dot{Mg}+\frac{1}{2}\dot{Fe})^3\,\overline{Si}^2$. Color green or black.

2 $\overline{Si}$	—1154·62		
1½ $\dot{Ca}$	527·23	A. 2161·35÷3·35 (sp. gr.) —645·2	
1 $\dot{Mg}$	254·50	B. 645·2÷5—129	C. 645·2÷14—46·1
½ $\dot{Fe}$	225·		
a. At. weight,	2161·35		

5. Pyroxene.—3d var. $(\frac{1}{2}\dot{Ca}+\frac{1}{2}\dot{Fe})^3\,\overline{Si}^2$. Hedenbergite.

2 $\overline{Si}$	—1154·62		
1½ $\dot{Ca}$	527·23	A. 2356·85÷3·5 (sp. gr.) —673·4	
1½ $\dot{Fe}$	675·00	B. 673·4÷5—134·7	C. 673·4÷14—48·1
a. At. weight,	2356·85		

6. Pyroxene—var. *Hudsonite.* A recent analysis in the Yale Laboratory, New Haven, by Mr. W. H. Brewer,* gives nearly the results of Beck for this mineral, but makes

* Mr. Brewer obtained the following for the composition of the Hudsonite; we add also Beck's results:—

	I.	Oxygen.		II.	III.	Beck.
Silica,	36·94	19·13	24·17	36·06	36·76	37·90
Alumina,	11·22	5·04		10·47	....	12·70
Peroxyd of iron,	*trace*	....		*trace*	....	....
Protoxyd of iron,	36·03	8·00	12·12	36·57	....	36·80
" manganese,	2·24	0·50		1·10	....	Mg 1·92
Lime,	12·71	3·62		....	....	11·40
	99·14					100·72

Beck uses the term *oxyd of iron;* but we infer from his accompanying remarks that he meant protoxyd. G. = 3·43—3·46, Brewer; 3·5, Beck.

the iron protoxyd, with but a trace of peroxyd. It affords very closely the formula $\dot{R}^3\,(\ddot{S}i, \ddot{A}l)^2$, or more precisely $\left(\frac{8}{12}\dot{F}e+\frac{0{\cdot}5}{12}\dot{M}n+\frac{3{\cdot}5}{12}\dot{C}a\right)^3\left(\frac{6{\cdot}33}{8}\ddot{S}i+\frac{1{\cdot}66}{8}\ddot{A}l\right)^2$. Multiplying by 4 throughout, the relation becomes $6\frac{1}{2}\ddot{S}i+1\frac{1}{2}\ddot{A}l+8\dot{F}e+\frac{1}{2}\dot{M}n+3\frac{1}{2}\dot{C}a$, which we here adopt, without farther reducing it, as the result will be the same.

$6\frac{1}{2}$ $\ddot{S}i$	=3656·3	*b.* atoms of acids and bases, 20.	*c.* atoms of elements, $57\frac{1}{2}$.
$1\frac{1}{2}$ $\ddot{A}l$	1069·6	A. 9778·4÷3·463 (mean sp. gr.)=2824, and 2824÷4=706	
8 $\dot{F}e$	3600·0	B. 2824÷20=141·2	C. 2824÷$57\frac{1}{2}$=48·9
$\frac{1}{2}$ $\dot{M}n$	222·3		
$3\frac{1}{2}$ $\dot{C}a$	1230·2		
a. At. weight,	9778·4		

7. Pyroxene—var. $\dot{F}e^3\,\ddot{S}i^2$. Asbestiform, analyzed by Grüner, (Comp. Rend. xxiv, 794.)

3 $\dot{F}e$	=1350·	*b.* atoms of acid and bases, 5.	*c.* atoms of elements, 14.
2 $\ddot{S}i$	1154·62	A. 2504·62÷3·712 (sp. gr.)=674·7	
a. At. weight,	2504·62	B. 674·7÷5=135	C. 674·7÷14=48·2

8. Pyroxene—var. $\dot{M}n^3\,\ddot{S}i^2$, Manganese Spar.

3 $\dot{M}n$	=1334·1	*b.* atoms of acid and base, 5.	*c.* atoms of elements, 14.
2 $\ddot{S}i$	1154·62	A. 2488·72÷3·634 (sp. gr.) =684·8	
a. At. weight,	2488·72	B. 684·8÷5=136·9	C. 684·8÷14=48·9

VIII. *Anatase, Horn Quicksilver.*

1. Anatase. $\ddot{T}i$ 514·7÷3·84 (sp. gr.) =134·0 C. 134·0÷3=44·66
2. Horn Quicksilver, $HgCl$, 1693·3÷6·48 (sp. gr.) =261·3 C. 261·3÷2=130·62

130·62 : 44·66, nearly as 3 : 1 ; and 130·62 : 134·0 = (nearly) 1 : 1.

IX. *Sulphur, Selenium* (acknowledged isomorph with Sulphur), *Scorodite.*

1. Sulphur. S, 200÷2·033 (sp. gr.) =98·4
2. Selenium. Se, 495·3÷4·3 (sp. gr.) =115
3. Scorodite.

1 $\ddot{A}s$	=1440·08	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 19.
1 $\dot{F}e$	1000·00	A. 2890÷3·23 (sp. gr.) =894·73	
4 $\dot{H}$	449·92	B. 894·73÷6=149·12	C. 894·73÷19=47·1
a. At. weight,	2890·00		

47·1, is very nearly $\frac{1}{2}$ the atomic volume of Sulphur; and 149 : 98·4=3 : 2

X. *Celestine, White Iron Pyrites, Graphic Tellurium.*

1. Celestine.

1 $\ddot{S}$	= 500·	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 6.
1 $\dot{S}r$	647·3	A. 1147·3÷3·9 (sp. gr.) =294·2	
a. At. weight,	1147·3	B. 294·2÷2=147·1	C. 294·2÷6=49·0

2. White Iron Pyrites.

$Fe+2S$	=750.	A. 750÷4·76 (sp. gr.)=157·56	C. 157·56÷3=52·52

3. Graphic Tellurium.

7 Te	=5612·6		*c.* atoms of elements, 10.
1 Ag	1350·	A. 9418·1÷8·28 (sp. gr.) =1137·5	
2 Au	2455·5		C. 1137·5÷10=113·75
a. At. weight,	9418·1		

The atomic volume C of graphic Tellurium is consequently double of that of White Iron Pyrites; the A relation is 7 : 1.

XI. *Monazite, Chromate of Lead.*

1. Monazite.

1 $\dot{P}$	= 892·3	*b.* atoms of acid and bases, 4.	*c.* atoms of elements, 12.
2 $\dot{C}e$	1350·0	A. 3086·2÷5 (sp. gr.) = 617·25	
1 $\dot{T}h$	843·9	B. 617·25÷4 = 154·3	C. 617·25÷12 = 51·44

a. At. weight, 3086·2 Marignac's at. wt. of Cerium, gives for C, 52

2. Chromate of Lead.

1 $\dot{C}r$	= 628·4	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 6.
1 $\dot{P}b$	1394·5	A. 2022·9÷6·06 (sp. gr.) = 333·8	

a. At. weights, 2022·9 B. 333·8÷2 = 166·9 C. 333·8÷6 = 55·6

There is some uncertainty as to Monazite, as the exact proportions of its bases are not accurately known.

XII. *Beryl, Nepheline.*

1. Beryl—using the old atomic weight:—

8 $\ddot{S}i$	= 4618·48	*b.* atoms of acid and bases, 11.	*c.* atoms of elements, 47.
1 $\ddot{B}e$	962·52	A. 6864·6÷2·732 (sp. gr.) = 2512·7	
2 $\ddot{A}l$	1283·60	B. 2512·7÷11 = 228·4	C. 2512·7÷47 = 53·46

a. At. weight, 6864·60 Awdejew's atomic weight gives for C, 46·44.

2. Nepheline.

3 $\ddot{S}i$	= 1731·93	*b.* atoms of acid and bases, 7.	*c.* atoms of elements, 26.
2 $\ddot{A}l$	1283·6	A. 3830·32÷2·6 (sp. gr.) = 1473·2	
$1\frac{2}{3}$ $\dot{N}a$	716·65	B. 1473·2÷7 = 210·5	C. 1473·2÷26 = 56·66
$\frac{1}{3}$ $\dot{K}$	98·14		

a. At. weight, 3830·32

XIII. *Pyroxene*, $\dot{R}^3\ddot{S}i^2$—*Acmite*, $\dot{N}a\ddot{S}i+\dot{F}e\ddot{S}i^2$—*Hornblende*, $\dot{R}^4\ddot{S}i^3$.

Acmite, as is well known, has the crystalline form of Pyroxene, although different in composition. Hornblende is peculiar in its cleavage and prevalent forms; yet as Rose has shown, its crystals have the same fundamental form as those of Pyroxene.

1. Pyroxene. As above deduced, A = 638·77–706; B = 127·55–141·2; C = 46·1–48·9

2. Acmite.

3 $\ddot{S}i$	= 1731·93	*b.* atoms of acid and bases, 5.	*c.* atoms of elements, 19.
1 $\dot{F}e$	1000·00	A. 3122·83÷3·4 (sp. gr.) = 918·5	
1 $\dot{N}a$	390·9	B. 918·5÷5 = 183·7	C. 918·5÷19 = 48·34

a. At. weight, 3122·83

3. Hornblende.

3 $\ddot{S}i$	= 1731·93	*b.* atoms of acid and bases, 7.	*c.* atoms of elements, 20.
3 $\dot{M}g$	763·5	A. 2846·92÷2·93 (sp. gr.) = 971·6	
1 $\dot{C}a$	351·49	B. 971·6÷7 = 138·8	C. 971·6÷20 = 48·58

a. At. weight, 2846·92

4. Hornblende, aluminous varieties.

a. Var. From Wolfsberg in Bohemia, analysed by Göschen.—The analysis corresponds to the ratio $2\frac{1}{2}\ddot{A}l+1\frac{1}{2}\dot{F}e+7\ddot{S}i+4\dot{C}a+5\dot{M}g$. We attempt no formula.

7 $\ddot{S}i$	= 4041·17	*b.* atoms of bases and acids, 20.	*c.* atoms of elements, 66.
$2\frac{1}{2}$ $\ddot{A}l$	1604·5	A. 9824·13÷3·15 (sp. gr.) = 3119	
$1\frac{1}{2}$ $\dot{F}e$	1500·0	B. 3119÷20 = 155·95	C. 3119÷66 = 47·25
4 $\dot{C}a$	1405·96		
5 $\dot{M}g$	1272·5	If sp. gr. = 3·167, then C = 47·0	

a. At. weight, 9824·13

b. Var. Carinthine. Analysis by Clausbruch (Pogg., lviii, 168), corresponding to $8\,\dot{S}i+1\frac{1}{2}\ddot{A}l+2\frac{2}{3}\dot{C}a+7\frac{1}{2}\dot{M}g+4\dot{F}e$.

8 $\dot{S}i$	=4618·48	*b.* atoms of acid and bases, $23\frac{1}{2}$.	*c.* atoms of elements, $66\frac{1}{2}$.
$1\frac{1}{2}$ $\ddot{A}l$	855·73	A. 10096·27÷3·127 (sp. gr.) =3229	
4 $\dot{F}e$	1800·00	B. 3229÷$23\frac{1}{2}$=138·4	C. 3229÷$66\frac{1}{2}$=48·43
$2\frac{2}{3}$ $\dot{C}a$	1004·26		
$7\frac{1}{2}$ $\dot{M}g$	1817·80		
a. At. weight,	10096·27		

c. Grammatite of Aker, Bonsdorff. The analysis gives $8{\cdot}17\,\dot{S}i+2{\cdot}17\,\ddot{A}l+3{\cdot}6\,\dot{C}a+8{\cdot}6\,\dot{M}g+0{\cdot}6\,\dot{F}e$. As above, we take the analysis as it is, without attempting to reduce it to the limits of a formula.

8·17 $\dot{S}i$ =	4716·6	*b.* atoms of acid and bases, 23·13.	*c.* atoms of elements, 69·1.
2·17 $\ddot{A}l$	1392·7	A. 9833·4÷2·95 (sp. gr.) =3333·3	
3·6 $\dot{C}a$	1265·4	B. 3333·3÷23·14=144	C. 3333·3÷69·1=48·24
8·6 $\dot{M}g$	2188·7		
0·6 $\dot{F}e$	270·0		
a. At. weight,	9833·4		

XIV. *Scapolite*, $(\dot{C}a, \dot{N}a)^3\,\ddot{S}i^2+2\ddot{A}l\,\ddot{S}i$—*Meionite*, $\dot{C}a^3\,\ddot{S}i+2\ddot{A}l\,\ddot{S}i$—*Wernerite*, $\dot{C}a^3\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i$—*Dipyre*, $4(\dot{C}a, \dot{N}a)\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i$.

These several compounds crystallize alike.

1. Scapolite.

4 $\ddot{S}i$	=2309·24	*b.* atoms of acid and bases, 9.	*c.* atoms of elements, 32.
2 $\ddot{A}l$	1283·6	A. 4686·72÷2·71 (sp. gr.) =1729·4	
1 $\dot{N}a$	390·9	B. 1729·4÷9=192·1	C. 1729·4÷32=54
2 $\dot{C}a$	702·98		
a. At. weight,	4686·72		

2. Meionite.

3 $\ddot{S}i$	=1731·93	*b.* atoms of acid and bases, 8.	*c.* atoms of elements, 28.
2 $\ddot{A}l$	1283·6	A. 4070÷2·612 (sp. gr.) =1558·2	
3 $\dot{C}a$	1054·47	B. 1558·2÷8=194·8	C. 1558·2÷28=55·65
a. At. weight,	4070·00		

3. Wernerite—From Tunaberg and Ersby, as analysed by Walmstedt and Nordenskiöld.

4 $\ddot{S}i$	=2309·24	*b.* atoms of acid and bases, 10.	*c.* atoms of elements, 37.
3 $\ddot{A}l$	1925·4	A. 5289·11÷2·77 (sp. gr.) =1909	
3 $\dot{C}a$	1054·47	B. 1909÷10=190·9	C. 1909÷37=51·6
a. At. weight,	5289·11		

4. Dipyre.

7 $\ddot{S}i$	=4041·17	*b.* atoms of acid and bases, 14.	*c.* atoms of elements, 51.
3 $\ddot{A}l$	1925·4	A. 7451·35÷2·646 (sp. gr.) =2816	
2 $\dot{N}a$	781·8	B. 2816÷14=201·1	C. 2816÷51=55·21
2 $\dot{C}a$	702·98		
a. At. weight,	7451·35		

5. Barsowite.—$(\dot{C}a, \dot{M}g)^3\,\ddot{S}i^2+3\ddot{A}l\,\ddot{S}i$. This scapolite-like mineral has A = 2133; B = 194; C = 52.

6. Wernerite—Wolff's analysis of a Pargas variety corresponds very closely with $\dot{C}a^2\ddot{S}i+2\ddot{A}l\,\ddot{S}i$ (although referred to the above Wernerite formula by Rammelsberg.)

3 $\ddot{S}i$	=1731·93	*b.* atoms of acid and bases, 7.	*c.* atoms of elements, 26.
2 $\ddot{A}l$	1283·6	A. 3718·51÷2·712 (sp. gr.) =1371·1	
2 $\dot{C}a$	702·98	B. 1371·1÷7=196	C. 1371·1÷26=52·7
a. At. weight,	3718·51		

Idocrase has its vertical axis to that of Scapolite as 5 : 4, and Zircon to that of Idocrase as 6 : 5. For comparison we here insert the atomic volume of Idocrase.

2 $\ddot{S}i$	=1154·62	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 19.
1 $\ddot{A}l$	641·8	A. 2883·72÷3·4 (sp. gr.)=848·16	
2½ $\dot{C}a$	937·3	B. 848·16÷6=141·36	848·16÷19=44·64
½ $\dot{F}e$	150·		
a. At. weight,	2883·72		

The atomic volumes of Scapolite, Idocrase and Zircon, are as 54 : 44·64 : 41·05.

XV. *Talc.*—Different varieties, $\dot{M}g^3\ddot{S}i^4$, $\dot{M}g^4\ddot{S}i^5$, $\dot{M}g\,\ddot{S}i$.

1. 4 $\ddot{S}i$ =2309·24 *b.* atoms of acid and base, 7. *c.* atoms of elements, 22.
   3 $\dot{M}g$ 763·5
   A. 3072·74÷2·7 (sp. gr.) =1138
   B. 1138÷7=162·57 C. 1138÷22=51·73
   a. At. weight, 3072·74

2. 5 $\ddot{S}i$ =2886·55 *b.* atoms of acid and base, 9. *c.* atoms of elements, 28.
   4 $\dot{M}g$ 1018·0
   A. 3904·55÷2·7 (sp. gr.) =1446
   B. 1446÷9=160·7 C. 1446÷28=51·64
   a. At. weight, 3904·55

3. 1 $\ddot{S}i$ = 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
   1 $\dot{M}g$ 254·5
   A. 831·81÷2·7 (sp. gr.) =308·1
   B. 308·1÷2=154 C. 308·1÷6=51·35
   a. At. weight, 831·81

XVI. *Epidote* $\dot{R}^3\ddot{S}i+2\ddot{R}\ddot{S}i$.—*Orthite* $2(\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i)+\dot{H}$ of the Ural; $\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i+\dot{H}$, of Hitteroe.

Orthite has been shown by Kokscharov (Min. Ges. St. Petersb., 1847, p. 147, and this Journal [2], viii, 125), to have the crystallization of Epidote. M : T in Epidote =114° 25′; in Uralorthite 114° 55′ Kokscharov; in Cerine 116° Rose. The above formulas of Orthite are recent results by Rammelsberg, (Poggendorff's Annalen, lxxvi, 98, 1849.) This author also calculates the atomic volume corresponding to the specimens analyzed, and obtains for Epidote having the formula $(\dot{C}a^3\ddot{S}i)+2(\frac{2}{3}\ddot{A}l+\frac{1}{3}\ddot{F}e)\,\ddot{S}i$, the atomic weight 4309·53, and 4309·53÷3·4 (sp. gr.)=1268.

For Orthite of the Urals (in which $6\dot{R}=1{\cdot}2\,\dot{F}e+2{\cdot}4(\dot{C}e,\dot{L}a)+2{\cdot}4\,\dot{C}a$; and $2\ddot{R}=1{\cdot}5\,\ddot{A}l+0{\cdot}5\,\ddot{F}e$), the atomic weight 6911·82; and 6911·82÷3·598=1921.

For the Orthite of Hitteroe, in which $3\dot{R}=0{\cdot}6\,\dot{F}e+1{\cdot}2\,\dot{C}e+1{\cdot}2\,\dot{C}a$; and $\ddot{R}=0{\cdot}7\,\ddot{A}l+0{\cdot}3\,\ddot{F}e$, the atomic weight 3513·72; and 3513·72÷3·459 (sp. gr.) =1017.

Rammelsberg thence observes that the atomic volumes of these minerals are as 1 : 1·5 : 0·8, "or perhaps" as 4 : 6 : 3.

If, however, as heretofore, we divide the aggregate atomic volume obtained by Rammelsberg by the number of atoms of the elements, we obtain

1. For Epidote	1268÷28=45·285
2. For Orthite of the Urals	1921÷40=48·025
3. For the Orthite of Hitteroe	1017÷21=48·43

A close relation, exhibiting satisfactorily the intimate relations of the compounds. Dividing by the number of atoms of bases and acids, gives respectively 1268÷8=158·5, 1921÷13=147·7, 1017÷7=145·3.

4. We add another example—a *Zoisite* from Rothlaue analyzed by Rammelsberg, (Pogg., lxviii, 509.)

3 $\dot{\ddot{S}}i$	=1731·93	*b.* atoms of acid and bases, 8.	*c.* atoms of elements, 28.
$1\frac{2}{3}$ $\ddot{A}l$	1069·7	A. 4189·43÷3·387 (sp. gr.) =1237	
$\frac{1}{3}$ $\dot{F}e$	333·33	B. 1237÷8=154·6	C. 1237÷28=44·2
3 $\dot{C}a$	1054·47		
a. At. weight,	4189·43		

Here 44·2 is but little below the determination for Epidote.

XVII. *The Feldspar Family.*—In Orthoclase and Albite, Ryacolite and Labradorite, Loxoclase and Oligoclase, we have three examples of dimorphism.

1. Orthoclase, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i^3$.—Form monoclinic.

4 $\dot{\ddot{S}}i$	=2309·24	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 23.
1 $\ddot{A}l$	641·80	A. 3539·90÷2·55 (sp. gr.) =1388	
1 $\dot{K}$	588·86	B. 1388÷6=231·3	C. 1388÷23=60·4
a. At. weight,	3539·90		

2. Albite, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i^3$.—Form triclinic.

4 $\dot{\ddot{S}}i$	=2309·24	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 23.
1 $\ddot{A}l$	641·80	A. 3341·94÷2·61 (sp. gr.) =1280·4	
1 $\dot{N}a$	390·9	B. 1280·4÷6=213·4	C. 1280·4÷23=55·67
a. At. weight,	3341·94		

3. Ryacolite, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i$.—Monoclinic.

2 $\dot{\ddot{S}}i$	=1154·62	*b.* atoms of acid and bases, 4.	*c.* atoms of elements, 15.
1 $\ddot{A}l$	641·80	A. 2236·83÷2·58 (sp. gr.) =867·0	
$\frac{3}{4}$ $\dot{N}a$	293·2	B. 867÷4=216·7	C. 867÷15=57·8
$\frac{1}{4}$ $\dot{K}$	147·21		
a. At. weight,	2236·83		

4. Labradorite, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i$.—Triclinic.

2 $\dot{\ddot{S}}i$	=1154·62	*b.* atoms of acid and bases, 4.	*c.* atoms of elements, 15.
1 $\ddot{A}l$	641·80	A. 2147·91÷2·7 (sp. gr.) =795·5	
1 $\dot{C}a$	351·49	B. 795·5÷4=198·9	C. 795·5÷15=53·03
a. At. weight,	2147·91		

5. Loxoclase, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i^2$.—Monoclinic.

3 $\dot{\ddot{S}}i$	=1731·93	*b.* atoms of acid and bases, 5.	*c.* atoms of elements, 19.
1 $\ddot{A}l$	641·80	A. 2779·52÷2·615 (sp. gr.) =1063	
$\frac{2}{3}$ $\dot{N}a$	244·31	B. 1063÷5=212·6	C. 1063÷19=56·0
$\frac{1}{4}$ $\dot{K}$	73·61		
$\frac{1}{4}$ $\dot{C}a$	87·87		
a. At. weight,	2779·52		

6. Oligoclase, $\dot{R}\,\dot{\ddot{S}}i+\ddot{A}l\,\dot{\ddot{S}}i^2$.—Triclinic.

3 $\dot{\ddot{S}}i$	=1731·93	*b.* atoms of acid and bases, 5.	*c.* atoms of elements, 19.
1 $\ddot{A}l$	641·80	A. 2751·49÷2·65 (sp. gr.) =1038·3	
$\frac{2}{3}$ $\dot{N}a$	260·66	B. 1038·3÷5=207·66	C. 1038·3÷19=54·647
$\frac{1}{4}$ $\dot{C}a$	117·16		
a. At. weight,	2751·49		

We observe that the triclinic form in each of these three cases of dimorphism has the *highest specific gravity*, and the *lowest atomic weight*, and therefore the *lowest atomic volume*.

7. Anorthite, $\dot{R}^3\,\breve{S}i+3\ddot{A}l\,\breve{S}i$.—Triclinic.

4 $\breve{S}i$	=2309·24	*b*. atoms of acid and bases, 10.	*c*. atoms of elements, 37.
3 $\ddot{A}l$	1925·40	A. 5289·11÷2·7=1959	
3 $\dot{C}a$	1054·47	B. 1959÷10=195·9	C. 1959÷37=52·95
a. At. weight,	5289·11		

8. Baulite, $\dot{R}\,\breve{S}i^2+\ddot{A}l\,\breve{S}i^6$.—Monoclinic.

8 $\breve{S}i$	=4618·48	*b*. atoms of acid and bases, 10.	*c*. atoms of elements, 39.
1 $\ddot{A}l$	641·80	A. 5750·16÷2·64 (sp. gr.) =2178·1	
½ $\dot{N}a$	195·45	B. 2178·1÷10=217·81	C. 2178·1÷39=55·85
½ $\dot{K}$	294·43		
a At. weight,	5750·16		

9. Vosgite, $\dot{R}^3\,\breve{S}i^2+3\ddot{A}l\,\breve{S}i$.—Triclinic.

5 $\breve{S}i$	=2886·55	*b*. atoms of acid and bases, 11.	*c*. atoms of elements, 41.
3 $\ddot{A}l$	1925·40	A. 5929·66÷2·737 (sp. gr.) =2166·5	
2⅖ $\dot{C}a$	843·58	B. 2166·5÷11=197	C. 2166·5÷41=52·84
⅖ $\dot{N}a$	156·36		
⅕ $\dot{K}$	117·77		
a. At. weight,	5929·66		

10. Andesine, $\dot{R}^3\,\breve{S}i^2+3\ddot{A}l\,\breve{S}i^2$.—Triclinic.

8 $\breve{S}i$	=4618·48	*b*. atoms of acid and bases, 14.	*c*. atoms of elements, 53.
3 $\ddot{A}l$	1925·40	A. 7776·15÷2·67 (sp. gr.) =2912·4	
1½ $\dot{N}a$	586·35	B. 2912·4÷14=208	C. 2912·4÷53=55·0
1 $\dot{C}a$	351·49		
½ $\dot{K}$	294·43		
a. At. weight,	7776·15		

11. Leucite, $\dot{R}^3\,\breve{S}i^2+3\ddot{A}l\,\breve{S}i^2$.—Monometric.

8 $\breve{S}i$	=4618·48	*b*. atoms of acid and bases, 14.	*c*. atoms of elements, 53.
3 $\ddot{A}l$	1925·40	A. 8310·46÷2·486=3343·15	
3 $\dot{K}$	1766·58	B. 3343÷14=238·8	C. 3343÷53=63·08
a. At. weight,	8310·46		

As Andesine and Leucite have essentially the same composition and the compound is therefore dimorphous, we here observe again that the triclinic form has the highest specific gravity and lowest atomic weight, and as a consequence, the lowest atomic volume.

XVIII. *Petalite*, $(\dot{L}i,\dot{N}a)^3\,\breve{S}i^4+4\ddot{A}l\,\breve{S}i^4$.—*Spodumene*, $(\dot{L}i,\dot{N}a)^3\,\breve{S}i^4+4\ddot{A}l\,\breve{S}i^2$, —*Andalusite*, $\ddot{A}l^3\,\breve{S}i^2$.

1. Petalite.

20 $\breve{S}i$	=11546·20	*b*. atoms of acid and bases, 27.	*c*. atoms of elements, 106.
4 $\ddot{A}l$	2567·20	A. 14815·31÷2·44 (sp. gr.) =6071·8	
2½ $\dot{L}i$	408·73	B. 6071·8÷27=224·96	C. 6071·8÷106=57·3
½ $\dot{N}a$	293·18		
a. At. weight,	14815·31		

2. Spodumene.

12 $\dot{S}i$	=6927·72	*b.* atoms of acid and bases, 19.	*c.* atoms of elements, 74.
4 $\dot{A}l$	2567·20	A. 10196·83÷3·17=3216·7	
2¼ $\dot{L}i$	408·73	B. 3216·7÷19=169·3	C. 3216·7÷74=43·47
¼ $\dot{N}a$	293·18		
a. At. weight,	10196·83		

Petalite has the structure of a ***feldspar***, although not conforming to the general rule for the feldspar family in having the oxygen of the peroxyds to that of the protoxyds as 3 : 1, but instead as 4 : 1. It also approaches Orthoclase in its atomic volume, B equalling 224·9 and C 57·31, while in Orthoclase B = 231·3 and C = 60·4. ***Spodumene***, on the contrary, although a lithia species like petalite, and having also the above ratio 4 : 1, differs in its cleavage and in its crystalline form, and is also widely removed from the feldspars in its atomic volume.

3. Andalusite.

2 $\dot{S}i$	=1154·62	*b.* atoms of acid and base, 5.	*c.* atoms of elements, 23.
3 $\dot{A}l$	1925·40	A. 3080·02÷3·2 (sp. gr.) =962·5	
a. At. volume,	3080·02	B. 962·5÷5=192·5	C. 962·5÷23=41·85

Andalusite has therefore the atomic volume of Spodumene, for C equals 41·85, while in the above it equals 43·47. Moreover the angle of the rhombic prism is nearly the same, it being in Andalusite 91° 33′, in Spodumene 93°. We may hence conclude that the crystallization of Spodumene is not oblique like the Feldspars and Petalite (although often so considered), but *trimetric* like Andalusite, and that ***the two species are isomorphous.***

XIX. *Analcime*, $3\dot{A}l\,\dot{S}i^2+\dot{N}a^3\,\dot{S}i^2+6\dot{H}$,—*Sodalite*, $Na\,Cl+\dot{N}a^3\,\dot{S}i+3\dot{A}l\,\dot{S}i$,—*Haüyne* $2\dot{C}a\,\dot{S}+\dot{N}a^3\,\dot{S}i+3\dot{A}l\,\dot{S}i$,—*Nosean* $\dot{N}a\,\dot{S}+\dot{N}a^3\,\dot{S}i+3\dot{A}l\,\dot{S}i$.

These species are introduced here for comparison with Leucite. They seem to show that the monometric form in these silicates is connected with a high atomic volume, the amount exceeding that of the monoclinic as well as triclinic feldspars.

1. Analcime.

8 $\dot{S}i$	=4618·48	*b.* atoms of bases and acid, 20.	*c.* atoms of elements, 65.
3 $\dot{A}l$	1925·4	A. 8391·46÷2·068 (sp. gr.) =4057·7	
3 $\dot{N}a$	1172·7	B. 4057·7÷20=202·88	C. 4057·7÷65=62·43
6 $\dot{H}$	674·88		
a. At. weight,	8391·46		

2. Sodalite.

4 $\dot{S}i$	=2309·24	*b.* atoms of bases and acid, 11.	*c.* atoms of elements, 39.
3 $\dot{A}l$	1925·4	A. 6141·54÷2·29 (sp. gr. of Vesuvian var.) =2682	
3 $\dot{N}a$	1172·7	B. 2682÷11=244	C. 2682÷39=68·77
1 Na	290·9		
1 Cl	443·3	Sp. gr. of Greenland Sodalite, 2·37. Thence C=66·45.	
a. At. weight,	6141·54		

3. Haüyne.

2 $\dot{S}$	=1000	*b.* atoms of bases and acid, 14.	*c.* atoms of elements, 49.
4 $\ddot{S}i$	2309·24	A. 7110·32÷2·45 (sp. gr.)=2902·2	
3 $\ddot{A}l$	1925·4	B. 2902·2÷14=207·3	C. 2902·2÷49=59·23
3 $\dot{N}a$	1172·7		
2 $\dot{C}a$	709·98		
a. At. weight,	7110·32		

4. Nosean.

4 $\ddot{S}i$	=2309·24	*b.* atoms of acids and bases, 12.	*c.* atoms of elements, 43.
3 $\ddot{A}l$	1925·4	A. 6298·24÷2·3 (sp. gr.) =2738·36	
4 $\dot{N}a$	1563·6	B. 2738·36÷12=228·2	C. 2738·36÷43=63·68
1 $\dot{S}$	500·00		
a. At. weight,	6298·24		

XX. *Kyanite*, $\ddot{A}l^3\ddot{S}i^2$—*Bucholzite*, $\ddot{A}l\ddot{S}i$.

1. Kyanite.

Atomic weight as for Andalusite, 3080·02. A. 3080·02÷3·62 (sp. gr.) =850·83
B. 850·83÷5=170·165 C. 850·83÷23=37·0

2. Bucholzite.

1 $\ddot{S}i$	= 577·31	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 9.
1 $\ddot{A}l$	641·80	A=1219·11÷3·4 (mean sp. gr.) =358·56	
a. At. weight,	1219·11	B. 358·56÷2=179·28	C. 358·56÷9=39·84

$\ddot{A}l^6\ddot{S}i^5$ (from Bowen's and Hayes's analyses of Sillimanite) gives (G=3·41, Bowen), A=1915·8; B=174·2; C=38·32.

The true nature of the mineral bucholzite has long been in doubt on account of the varying results of analysts. Successive experimenters have placed Sillimanite with kyanite and bucholzite; and finally Prof. Silliman, Jr., has recently united the three. The above results show that the distinct chemical compounds are identical nearly in atomic volume; we may conclude therefore that three or more compounds exist, as Hermann assumed in his paper on "heteromerism;" and analysts instead of proving one another in error have in fact examined the different species.

We observe also that of the two forms of the compound $\ddot{A}l^3\ddot{S}i^2$, the *triclinic*, as before, has the higher specific gravity and lower atomic weight, and consequently the lower atomic volume.

XXI. *Leucopyrite*, Fe As—*Mispickel*, Fe $\dot{S}^2$+Fe As,—*White Iron Pyrites*, Fe $\dot{S}^2$.

1. Leucopyrite.

1 As	=940		*c.* atoms of elements, 2.
1 Fe	350	A. 1290÷7·228 (sp. gr.) =178·47	
a. At. weight,	1290		C. 178·47÷2=89·24
		[If As is a double atom, then 178·47÷3=59·49]	

2. Mispickel.

1 As	=940		*c.* atoms of elements, 5.
2 S	400	A. 2040÷6·127 (sp. gr.)=333	
2 Fe	700		C. 333÷5=66·6
a. At weight,	2040	[Considering As a double atom, 333÷6=55·5]	

3. White Iron Pyrites.

2 S	=400		*c.* atoms of elements, 3.
1 Fe	350	A. 750÷4·76 (sp. gr.) =157·56	
a. At. weight,	750		C. 157·56÷3=52·52

The atomic volumes of these minerals are,

If As is a single atom,	89·24	66·6	52·52
If As is a double atom,	59·49	55·5	52·52

These species have each a rhombic form; but as Prof. G. Rose has observed, they appear to differ too widely to be considered isomorphous. The angles M : M are respectively 122°26′, 111°53′ and 106°30′. This chemist also remarks that the elements arsenic and sulphur are very different in crystallization, and therefore we have no good authority for assuming them to be isomorphous. If we admit As to be a single atom the atomic volumes are widely different; but if a double atom, they approximate rather closely.

In this connection, the atomic volume of *olivenite* (with which *Libethenite* is isomorphous) may be stated. The rhombic prism has M : M (∞P) = 109°10′, $\breve{P}\infty$ = 84°45′; while in white iron pyrites ∞P = 106°30′ and $\breve{P}\infty$ = 81°50′, in Mispickel ∞P = 111°53′ and $\breve{P}\infty$ = 80°8′.

1. Olivenite.

¾ $\dot{A}s$	=1080·06	*b.* atoms of acids and bases, 6.	*c.* atoms of elements, 16.
¼ $\dot{P}$	223·1	A. 3402·04÷4·135 (sp. gr.) =822·74	
4 Ċu	1986·4	B. 822·74÷6=137·12	C. 822·74÷16=51·42
1 Ḣ	112·48	[If As is a double atom, then *c*=17, and C=48·4.]	
a. At. volume,	3402·04		

2. Libethenite.

1 $\dot{P}$	= 892·3	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 16.
4 Ċu	1986·4	A. 2991·18÷3·7 (sp. gr.) =808·43	
1 Ḣ	112·48	B. 808·43÷6=134·74	C. 808·43÷16=50·53
a. At. volume,	2991·18		

XXII. *Nitrate of Soda—Carbonate of Manganese—Carbonate of Zinc—Light Red Silver Ore.* (see p. 220.)

1. Nitrate of Soda, $\dot{N}a\dot{N}$; R : R=106° 33′.

1 Ṅa	= 390·9	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 8.
1 $\dot{N}$	675·06	A. 1065·96÷2·1 (sp. gr.) =507·6	
a. At. weight,	1065·96	B. 507·6÷2=253·8	C. 507·6÷8=63·45

2. Carbonate of Manganese, $\dot{M}n\ddot{C}$; R : R=106°51′.

1 Ṁn	= 444·7	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 5.
1 C̈	275·	A. 719·7÷3·592=200·4	
a. At. weight,	719·7	B. 200·4÷2=100·2	C. 200·4÷5=40·1

3. Carbonate of Zinc, $\dot{Z}n\ddot{C}$, R : R=107°40′.

1 Żn	= 506·6	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 5.
1 C̈	275·	A. 781·6÷4·4 (sp. gr.) =177·6	
a. At. weight,	781·6	B. 177·6÷2=88·8	C. 177·6÷5=35·5

4. Light Red Silver Ore, $3Ag\,S + As\,S^3$; R : R = 107°36′.

3 Ag	=4050·00	*b.* atoms of base and acid, 2. *c.* atoms of elements, 10.
1 As	940·08	A. 6190·08 ÷ 5·5 = 1125
6 S	1200·00	B. 1125 ÷ 2 = 562·5. C. 1125 ÷ 10 = 112·5.
a. At. weight,	6190·08	C′. 1125 ÷ 11 (if As is double) = 107

5. Dark Red Silver Ore, $3Ag\,S + Sb\,S^3$.

3 Ag	=4050·0	A. 6362·80 ÷ 5·8 (sp. gr.) = 1183
Sb	1612·8	C. 1183 ÷ 10 = 118·3
6 S	1200·	
a. At. weight,	6862·8	

C in nitrate of soda and carbonate of manganese (which are nearly alike in angle) is as 2 : 3. Carbonate of zinc, isomorphous with carbonate of manganese, has C = 35·5, the angle R : R being a degree larger. The relation between C in carbonate of zinc and light red silver ore (in which the angle is nearly the same) approaches closely 1 : 3,—three times C of zinc being 106·5, while C in the silver ore is 112·5.

XXIII. *Arragonite*, M : M, 116°10′—*White Lead ore*, 117°13′—*Strontianite*, 117°19′—*Witherite*, 118°30′—*Nitrate of Potash*, 119°—*Bournonite*, 115°16′.

1. Arragonite.

1 Ca	= 351·49	*b.* atoms of acid and base, 2. *c.* atoms of elements, 5.
1 C	275·	A. 626·99 ÷ 2·93 (sp. gr.) = 216
a. At. weight,	626·49	B. 216 ÷ 2 = 108 C. 216 ÷ 5 = 43·2

2. White Lead ore.

1 Pb	=1394·5	A. 1669·5 ÷ 6·6 (sp. gr.) = 253
2 C	275·0	B. 253 ÷ 2 = 126·5 C. 253 ÷ 6 = 50·6
a. At. weight,	1669·5	

3. Strontianite.

1 Sr	= 647·3	A. 922·3 ÷ 3·66 (sp. gr.) = 252·7
1 C	275·	B. 252 ÷ 2 = 126 C. 252 ÷ 5 = 50·54
	922·3	

4. Witherite.

1 Ba	= 956·5	A. 1231·5 ÷ 4·3 (sp. gr.) = 286·4
1 C	275·	B. 286·4 ÷ 2 = 143·2 C. 286·4 ÷ 5 = 57·3
	1231·5	

5. Nitrate of Potash.

1 K	= 588·86	*b.* atoms of acid and base. *c.* atoms of elements, 8 [or 9].
1 N	675·06	A. 1263·92 ÷ 1·937 (sp. gr.) = 652·5
a. At. weight,	1263·92	B. 652·5 ÷ 2 = 326·2 C. 652·5 ÷ 8 = 81·56

6. Bournonite.

6 Cu	=2370·	*c.* atoms of elements, 33.
6 Pb	7767·	A. 18585·4 ÷ 5·766 (sp. gr.) = 3223·3
3 Sb	4848·4	C. 3223·3 ÷ 33 = 97·5
18 S	3600·	[3223·3 ÷ 36 (Sb being double) = 89·5]
a. At. weight,	18585·4	

We have added several acknowledged isomorphs that the nature of the series may be understood, preparatory for comparison with the other species. This series is,

116°10′	117°13′	117°19′	118°30′
43	50·6	50·54	57·3

In the above series there is a change of 14·3 in atomic volume for a change of 2°20′ (or 140′) of angle. This is equivalent very nearly to 0·1 for 1′. The differences between the first and second in this series and between the third and fourth correspond nearly with this rate.

To appreciate the relation of atomic volume between nitrate of potash, and the other species of the series, we compare it with witherite which is nearest it in angle, and find the ratio nearly of 3 : 2. With reference to bournonite, we should compare with arragonite, which is nearest it in angle; or perhaps more correctly with a number still smaller than the atomic volume of arragonite, since the angle is nearly a degree less. The true ratio we cannot decide upon without further investigation.

We observe that the atomic volume in the arragonite series increases with the angle while, as shown by Kopp, it diminishes in the calc series. Moreover the species with a prismatic form have a higher atomic volume than the rhombohedral; and in the species calc spar the two series overlap.

Żn C̄	Ṁg C̄	Ḟe C̄	Ṁn C̄	Ċa C̄	Ṗb C̄	Ṡr C̄	Ḃa C̄
107°46′	107°25′	107°0′	106°51′	105°15′			
35·5	36·25	37·70	40·1	46·24			
				43·	50·6	50·54	57·3
				116°10′	117°13′	117°19′	118°30′

We should hence expect that if either of these species were dimorphous like calc spar, it would be those nearest to calc spar.

The species chrysolite and those of that series differ from arragonite in having $\dot{M} : \dot{M} = 119° - 120°$, and as the angle of the arragonite series enlarges, the crystallization of the two approximates. The atomic volume of the chrysolite series varies from 40 to 46, and this is near arragonite.

We add here the calculations for two species, one of which approaches chrysoberyl and the other arragonite.

Copper glance (Ċu S) has $\dot{M} : \dot{M} = 119°35′$, and a brachydiagonal prism $= 125°40′$, while chrysoberyl has $\dot{M} : \dot{M} = 119°51′$ and a brachydiagonal prism $= 130°$.

Ċu	= 793·2	A. 993·2 ÷ 5·7 (sp. gr.) = 174	
S	200·	C. 174 ÷ 3 = 58	
	993·2	[or if Ċu is a single atom, 174 ÷ 2 = 67]	

As 2Cu is isomorphous with 1Ag and other metals, the last value of the atomic volume appears to be most correct. This gives

the ratio to the chrysolite series of 3 : 2. Serpentine has 44, to which if one-half be added, it becomes the atomic volume very nearly of copper glance.

Brittle Silver Ore (Sprödglaserz=6Ag S+Sb S^3) has M : M=115°39′, and one of its brachydiagonal prisms 72°32′; while arragonite has the corresponding angles 116°10′ and 69°22′.

6 Ag	=8100·	A. 11512·8÷6·5=1771
1 Sb	1612·8	C 1771÷16=110·7
9 S	1800·	
	11512·8	

This result gives the ratio of 3 : 1.

We do not decide here whether these minerals are proper isomorphs or not of the groups with which they are compared.

Topaz in one position has nearly the axes of chrysoberyl. They are given by von Kobell as follows—

For Chrysoberyl, 0·5800 : 1 : 0·4702
For Topaz, 0·4745 : 1 : 0·5281

and the latter is the same approximately as the former reversed.

Calculating the atomic volume of topaz $(Al F^3+Si F^3)+2\dot{Al}^3 \dot{Si}^2$, we find

4 $\dot{Si}$	= 2309·24	c. atoms of elements, 55.
6 $\dot{Al}$	3850·80	A. 8204·15÷3·5(sp. gr.) =2344·0
2 Al	341·8	C. 2344÷55=42·6
6 F	1425·0	
1 Si	277·31	
	8204·15	

The atomic volume thus corresponds with that of the chrysolite series.

The following are some comparisons of dimetric and hexagonal species, alike in the length of the vertical axis. The coincidences of atomic volume cannot be deemed accidental.

	Axis.	Atomic volume.
Vesuvian, *dimetric*,	0·5345	44·64
Dioptase, *rhombohedral*,	0·5295	45·44
Rutile, *dimetric*,	0·6555	40·7
Arsenic, *rhombohedral*,	0·6938	163 (=4×40·75)
Scapolite, *dimetric*,	0·44	54·
Nepheline, *rhombohedral*,	0·4629	56·66
Beryl, "	0·4993	53·46
Tungsten, *dimetric*,	1·0488	50·3
Chabazite, *rhombohedral*,	1·0798	51·5

It is obvious that these observations are but the introduction to a subject of great extent, and of the widest interest to science.

I defer for another occasion what had been prepared upon the monometric species, and conclude with a table of the results here published, and a brief enunciation of some of the conclusions flowing from the facts detailed.

A TABULAR VIEW OF THE RESULTS.

The relations of atomic volume will be at once apparent from the following table; 1, as exhibited in the column of aggregate atomic volumes (column A),—2, in that of the aggregate divided by the number of atoms of acids and bases (column B),—3, that of the aggregate divided by the number of atoms of the elements (column C).

1. *Crystallization clinometric.*

	A.	B.	C.
1. Pyroxene, monoclinic, 1st var., $(\dot{C}a, \dot{M}g)^3 \ddot{S}i^2$,	637·	127·4	45·5
2d var., $(\dot{C}a, \dot{M}g, \dot{F}e)^3 \ddot{S}i^2$,	645·2	129·	46·1
3d var., (Hedenbergite,)	673·4	134·7	48·1
4th var., (Hudsonite,)	706·0	141·2	48·9
5th var., $\dot{F}e^3 \ddot{S}i^2$,	674·7	135·	48·2
6th var., $\dot{M}n^3 \ddot{S}i^2$,	684·8	136·9	48·9
2. Acmite, monoclinic,	918·5	183·7	48·34
3. Hornblende, " 1st var.,	971·6	138·8	48·58
2d var., (aluminous,)	. .	155·95	47·25
3d var., "	. .	138·4	48·43
4th var.,	. .	144·0	48·24
4. Borax, monoclinic,	1391·6	107·0	46·38
5. Glauber salt, "	1290·5	107·54	49·6
1. Epidote, monoclinic,	1268·	158·5	45·285
2. Zoisite, "	1237·	154·6	44·2
3. Orthite of the Urals, monoclinic,	1921·	147·8	48·025
4. Orthite of Hitteroe, "	1017·	145·3	48·43
1. Orthoclase, monoclinic,	1388·	231·3	60·4
2. Ryacolite, "	867·	216·7	57·8
3. Loxoclase, "	1063·	212·6	56·0
4. Baulite, "	2178·1	217·81	55·85
5. Albite, triclinic,	1280·4	213·4	55·67
6. Labradorite, "	795·5	198·9	53·03
7. Oligoclase, "	1038·3	207·66	54·647
8. Anorthite, "	1959·	195·9	52·95
9. Vosgite, "	2166·5	197·	52·84
10. Andesine, "	2912·4	208·	55·0
11. Petalite, "	6071·8	224·96	57·3
1. Kyanite, triclinic, $\ddot{A}l^3 \ddot{S}i^2$,	850·83	170·165	37·0
2. Bucholzite, " $\ddot{A}l \ddot{S}i$,	358·56	179·28	39·84
3. Sillimanite, $\ddot{A}l^6 \ddot{S}i^5$ (Bowen's analysis),	1915·8	174·2	38·32
1. Chromate of lead, monoclinic,	333·8	166·9	55·6
2. Monazite, "	617·25	154·3	51·44

2. *Hexagonal or Rhombohedral.*

	A.	B.	C.
1. Specular iron, 85°58′,	192·	. .	38·4
2. Alumina, (Corundum,) 86°04′,	161·7	. .	32·3
3. Phenacite, 83°12′,	354·	88·5	35·4
4. Arsenic, 85°04′,	. .	. .	163·
5. Antimony, 87°35′	. .	. .	240·65
6. Bismuth, 87°40′,	. .	. .	135·75
7. Tellurium, 86°57′,	. .	. .	129·36
8. Osmium, 84°52′,	. .	. .	124·26
1. Quartz, 94°15′,	218·	. .	54·5
2. Chabazite, 94°46′,	4582·4	143·	51·5
1. Cinnabar, 71°47′,	180·	. .	90·
2. Eudialyte, 73°40′,	2382·	183·2	58·1
1. Beryl, (old at. wt. of Glucina,)	2512·7	228·4	53·46
2. Nepheline,	1473·2	210·5	56·66
1. Talc, $\dot{M}g^3\,\ddot{S}i^4$,	1138·	162·57	51·73
2. " $\dot{M}g^4\,\ddot{S}i^5$,	1446·	160·7	51·64
3. " $\dot{M}g\,\ddot{S}i$,	308·1	154·	51·35
1. Carbonate of lime, 105°05′, (from Kopp,)	231·20	165·60	46·24
2. " lime and magnesia (dolomite,) 106°15′,	202·36	101·18	40·47
3. " manganese, 106°51′,	200·4	100·2	40·1
4. Nitrate of soda, 106°33′,	507·6	253·8	63·45
5. Carbonate of iron, 107°,	188·50	94·25	37·70
6. " iron and magnesia, (mesitine,) 107°14′,	186·26	93·13	37·25
7. " magnesia, 107°25′,	181·25	90·62	36·25
8. " zinc, 107°40′,	177·6	88·8	35·5
9. Light red silver ore, 107°36′,	1125·	562·5	112·5
10. Dark red silver ore, 108°18′,	1183·	591·5	118·3

3. *Crystallization trimetric.*

1. Chrysoberyl, (new atomic weight,)	216·18	108·9	30·9
" old atomic weight,	1300·9	185·8	37·16
" von Kobell's at. wt.,	433·7	144·6	36·14
2. Chrysolite,	416·	104·	41·6
3. Villarsite,	1916·3	100·86	41·65
4. Serpentine,	2068·5	109·	44·9
5. Epsom salt,	881·	98·	44·
6. Picrosmine,	1587·	122·	46·68
1. Topaz,	2344·	. .	42·6
1. Sulphur,	98·4	. .	98·4
2. Scorodite,	894·73	149·12	47·1
3. Selenium, (acknowledged isomorphous with sulphur,)	115·	. .	115·
1. White iron pyrites, (dimorph with common pyrites,) 106°36′,	157·56	. .	52·52
2. Graphic tellurium, 107°44′,	1137·5	. .	113·75
3. Celestine, 104°,	294·2	147·1	49·
4. Heavy spar, 101°40′,	323·64	161·82	53·94
5. Anglesite, 103°49′,	301·67	150·83	50·27

	A.	B.	C.
1. Andalusite,	962·5	192·5	41·85
2. Spodumene,	3216·7	169·3	43·47
1. Leucopyrite—As, a single atom,	178·47	. .	89·24
As, a double atom,	. .	. .	59·49
2. Mispickel —As, a single atom,	333·	. .	66·6
As, a double atom,	. .	. .	55·5
3. White iron pyrites, (as above,)	157·56	. .	52·52
4. Olivenite,	822·74	137·12	51·42
5. Libethenite,	808·43	134·74	50·53
1. Arragonite, 116°10′,	216·	108·	43·2
2. White lead ore, 117°13′,	253·	126·5	50·6
3. Strontianite, 117°19′,	252·	126·	50·54
4. Witherite, 118°30′,	286·4	143·2	57·3
5. Nitrate of potash, 119°,	652·5	326·2	81·56
6. Bournonite, 115°16′,	3223·3	. .	97·5
1. Copper glance, 119°35′,	174·	. .	58 or 67
1. Brittle silver ore,	1771·	. .	110·7

4. *Crystallization dimetric.*

1. Scheelite, (tungstate of lime,)	301·6	150·8	50·3
2. Tungstate of lead,	355·9	177·9	59·3
3. Fergusonite,	967·5	138·2	57·0
1. Zircon,	370·3	185·15	41·15
2. Rutile,	122·3	. .	40·7
3. Tin ore,	134·4	. .	44·8
1. Scapolite,	1729·4	192·1	54·
2. Meionite,	1558·2	194·8	55·65
3. Wernerite,	1909·	190·9	51·6
4. Dipyre,	2816·	201·1	55·21
5. Barsowite,	2133·	194·	52·
6. Wernerite, Pargas,	1371·1	196·	52·7
7. Gehlenite (Rammelsberg's analysis),	2505·3	156·6	51·13
1. Idocrase,	848·16	141·36	44·64
1. Anatase,	134·0	. .	44·66
2. Horn quicksilver,	261·3	. .	130·65

5. *Crystallization monometric.*

1. Leucite,	3343·	238·8	63·08
2. Analcime,	4057·7	202·88	62·43
3. Haüyne,	2902·2	207·3	59·23
4. Nosean,	2738·36	228·2	63·68
5. Sodalite—Sp. gr.=2·29,	2682·	244·	68·77
Sp. gr.=2·37,	. .	. .	66·45

Conclusions from the preceding facts.

I. The law of Isomorphism, in view of the facts detailed, has greatly widened limits. It includes the received law—Like or homologous compounds of isomorphous elements are isomorph-

ous; and also the more general law,—Unlike compounds, of the same or different elements, may be isomorphous, and when so, they are alike or proportional in atomic volume.

II. Cleavage may differ among substances, and yet the species be isomorphous. Thus augite and hornblende have different cleavage; anatase and horn quicksilver; sulphur and scorodite. This is a point, however, which requires much more investigation.

III. The relations of atomic volume shown in the three columns are all of interest, but especially those in the *third* or C column. The C relation is seen to be in general a relation of approximate *equality*, while the A relation when simple is usually one of multiple ratio; and sometimes it is far from simple. The C relation exhibits the comparative character of the monoclinic, triclinic and monometric feldspars, in a simple and obvious manner, while from the A relation, no deduction could be made: and so in other cases where general principles are concerned. The C relations often show a consistent difference between a substance with its allies and others unlike, when no such difference is apparent in the A relations. The C relation moreover exhibits the differences which are compatible with a ratio of equality, and hence enables us to compare more correctly the A relations. It is unnecessary to review here the ratios in the C column. We mention only a few cases of the ratios (approximate) apparent in the A column which in many cases are simple and deserve full consideration. We take the number for the species first mentioned in each paragraph as the unit for comparison with the others.

1. Pyroxene, dif. var., 1; acmite $1\frac{1}{2}$; hornblende $1\frac{1}{2}$; borax 2; glauber salt 2.

2. Epidote 1; zoisite 1; Ural orthite $1\frac{1}{2}$; Hitteroe orthite $\frac{4}{5}$.

3. Orthoclase 1; ryacolite $\frac{3}{4}$; loxoclase $\frac{3}{4}$; baulite $1\frac{1}{2}$; albite 1; labradorite $\frac{3}{4}$; anorthite $1\frac{1}{2}$; vosgite $1\frac{1}{2}$; andesine $1\frac{1}{2}$; petalite $4\frac{1}{2}$.

4. Kyanite 1; bucholzite $\frac{4.2}{10.0}$; sillimanite (one var.) $2\frac{1}{2}$.

5. Quartz 1; chabazite 20. In deducing the ratio here as in other cases, we have some reference necessarily to the difference observed in the C ratios.

6. Talc, 1st var., 1; 2d var., $1\frac{1}{2}$; 3d var., $\frac{2.7}{10.0}$. In the C column the numbers are nearly equal.

7. Chrysolite 1; chrysoberyl $\frac{1}{2}$ (or 1); villarsite 4·6; serpentine 5; Epsom salt 2; picrosmine $3\frac{1}{2}$.

8. Rutile 1; zircon 3.—9. Scheelite 1; fergusonite 3.

We do not pursue this further, as the ratios are readily deducible from the table.

IV. The view of Scheerer, that three of water may replace one of magnesia, if true, is only true for a special case or set of cases, and is subordinate to the more general law of atomic volume. If true, we should expect, in dividing the aggregate atomic volume by the number of atoms of the elements, that it would be right to reckon three atoms of water as eqivalent to one of magnesia, instead of counting each element as equal to one; but the facts observed are opposed to this course.

The Gerhardtian principle that protoxyd bases replace peroxyds, is also, when true, only a special case. The relations of the feldspars do not appear to be explicable on Gerhardt's principle; nor the relations of the varieties of scapolite or hornblende.

V. Species of the same atomic volume may be wholly unlike in crystallization, and hence volume alone does not seem to determine the form. Quartz has the atomic volume (C) of the feldspars—an interesting fact in view of their frequent association—and the A relation between it and albite is 1:6; yet there is no isomorphism between them. The fact that the two forms of a dimorphous substance differ but little in the calculated atomic volume, (often much less than one of the forms differs from another isomorphous with it,) appears to be a case in point. Yet if instances of dimorphism are also instances of isomerism, it is possible that the volume may actually be double that which is deduced. We have much therefore, to ascertain on this point, before we can determine the true relation of form to volume.

VI. There are difficulties in the way of applying these principles to some compounds, arising from doubts with regard to the atomic weights. But, as in the case of hydrogen, (which is doubled by the Berzelian school,) these investigations seem to afford data for arriving at the truth.

VII. Since the relations of atomic volume are exhibited through the volume of the elemental molecules of compounds, it may be inferred that *the elemental molecules are not combined together or united with one another in a compound; but that, under their mutual influence, each is changed alike and becomes a mean result of the molecular forces in action.* If the elemental molecules were actually combined, as is usually supposed, the atomic volume of the aggregate should be the atomic volume of the compound; so that in all comparisons between different substances, these aggregate results should present the true relation. But, it appears that the true atomic volume relation is found in the elemental molecules of compounds, and much less clearly or uniformly in the aggregate results. This inference is at variance with received ideas on chemical combination; yet if our premises are correct—we admit they need farther investigation—we see not how to avoid it.

We add an additional word upon the name applied to isomorphism among unlike compounds. *Heteromerism*, as stated, is unmeaning, this term being the correlative of *isomerism*, which has no relation to isomorphism. *Heteromerous isomorphism* is in itself applicable; but the word *isomerous* is in use, and heteromerous, if employed at all, should correspond in signification. As the above terms are therefore objectionable, we suggest as appropriate and significant, the expressions *isonomic* and *heteronomic isomorphism;* the isomorphism being in one case between homologous substances, or those of like law or proportion in constitution,—and in the other between substances unlike in constitution.

ART. XXVI.—*Observations on the Size of the Brain in various Races and Families of Man;* by SAMUEL GEORGE MORTON, M.D.*

I HAVE great pleasure in submitting to the Academy the results of the internal measurements of six hundred and twenty-three human crania, made with a view to ascertain the relative size of the brain in various races and families of man.

These measurements have been made by the process invented by my friend, Mr. J. S. Phillips, and described in my Crania Americana, p. 253, merely substituting leaden shot, one-eighth of an inch in diameter, in place of the white mustard-seed originally used. I thus obtain the *absolute capacity of the cranium, or bulk of the brain, in cubic inches;* and the results are annexed in all those instances in which I have had leisure to put this revised mode of measurement in practice. I have restricted it, at least for the purpose of my inferential conclusions, to the crania of persons of sixteen years of age and upwards, at which period the brain is believed to possess the adult size. Under this age, the capacity-measurement has been resorted to only for the purpose of collateral comparison; nor can I avoid expressing my satisfaction at the singular accuracy of this method, since a skull of a hundred cubic inches, if measured any number of times with reasonable care will not vary a single cubic inch.

All these measurements have been made with my own hands. I at one time employed a person to assist me; but having detected some errors in his measurements, I have been at the pains to revise all that part of the series that had not been previously measured by myself. I can now, therefore, vouch for the accuracy of these multitudinous data, which I cannot but regard as a novel and important contribution to Ethnological science.

I am now engaged in a memoir which will embrace in detail the conclusions that result from these data; and meanwhile I submit the following tabular view of the prominent facts. (See opposite page.)

The measurements of children, idiots and mixed races are omitted from this table, excepting only in the instance of the Fellahs of Egypt, who, however, are a blended stock of two *Caucasian* nations,—the true Egyptian and the intrusive Arab, in which the characteristics of the former greatly predominate.

No mean has been taken of the Caucasian race† collectively, because of the very great preponderance of Hindu, Egyptian and

* From the Proceedings of the Academy of Natural Sciences, Philadelphia, October, 1849.

† It is necessary to explain what is here meant by the word *race*. Further researches into Ethnographic affinities will probably demonstrate that what are now termed the *five races* of men, would be more appropriately called *groups;* that each

Table showing the Sizes of the Brain in cubic inches, as obtained from the internal measurement of 623 Crania of various Races and Families of Man.

Races and Families.	No. of Skulls.	Largest I. C.	Smallest I. C.	Mean.	Mean.
MODERN CAUCASIAN GROUP.					
TEUTONIC FAMILY.					
Germans,	18	114	70	90	92
English,	5	105	91	96	
Anglo-Americans,	7	97	82	90	
PELASGIC FAMILY. Persians, Armenians, Circassians,	10	94	75	84	
CELTIC FAMILY. Native Irish,	6	97	78	87	
INDOSTANIC FAMILY, Bengalees, &c.	32	91	67	80	
SEMITIC FAMILY. Arabs,	3	98	84	89	
NILOTIC FAMILY. Pellahs,	17	96	66	80	
ANCIENT CAUCASIAN GROUP.					
From the Catacombs. PELASGIC FAMILY. Græco-Egyptians,	18	97	74	88	
From the Catacombs. NILOTIC FAMILY. Egyptians,	55	96	68	80	
MONGOLIAN GROUP.					
CHINESE FAMILY.	6	91	70	86	
MALAY GROUP.					
MALAYAN FAMILY.	20	97	68	86	85
POLYNESIAN FAMILY.	3	84	82	83	
AMERICAN GROUP.					
TOLTECAN FAMILY. Peruvians,	155	101	58	75	79
Mexicans,	22	92	67	79	
BARBAROUS TRIBES Iroquois, Lenapé, Cherokee, Shoshoné, &c.	161	104	70	84	
NEGRO GROUP.					
NATIVE AFRICAN FAMILY.	62	99	65	83	83
AMERICAN-BORN NEGROES.	12	89	73	82	
HOTTENTOT FAMILY.	3	83	68	75	
ALFORIAN FAMILY. Australians,	8	83	63	75	

Fellah skulls over those of the Germanic, Pelasgic and Celtic families. Nor could any just *collective* comparison be instituted between the Caucasian and Negro groups in such a table, unless the small-brained people of the latter division (Hottentots, Bushmen and Australians) were proportionate in number to the Hindoos, Egyptians and Fellahs of the other group. Such a computation, were it practicable, would probably reduce the Caucasian average to about 87 cubic inches, and the Negro to 78 at most, perhaps even to 75, and thus confirmatively establish the difference of at least nine cubic inches between the mean of the two races.

Large as this collection already is, a glance at the Table will show that it is very deficient in some divisions of the human family. For example, it contains no crania of the Eskimaux, Fuegians, Californians or Brazilians. The skulls of the great divisions of the Caucasian and Mongolian races are also too few for satisfactory comparison, and the Sclavonic and Tchudic (Finnish) nations, together with the Mongol tribes of Northern Asia and China, are among the especial *desiderata* of this collection.

Among the facts elicited by this investigation are the following:

1. The Teutonic or German race, embracing, as it does, the Anglo-Saxons, Anglo-Americans, Anglo-Irish, &c., possesses the largest brain of any other people.

2. The nations having the smallest heads, are the ancient Peruvians and Australians.

3. The Barbarous tribes of America possess a much larger brain than the demi-civilized Peruvians or Mexicans.

4. The ancient Egyptians, whose civilization ante-dates that of all other people, and whose country has been justly called "the cradle of the arts and sciences," have the least-sized brain of any Caucasian nation, excepting the Hindoos; for the very few Semi-

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of these groups is again divisible into a greater or smaller number of primary races, each of which has expanded from an aboriginal nucleus or centre. Thus I conceive that there were several centres for the American group of races, of which the highest in the scale are the Toltecan nations, the lowest the Fuegians. Nor does this view conflict with the general principle, that all these nations and tribes have had, as I have elsewhere expressed it, a common origin; inasmuch as by this term is meant only an indigenous relation to the country they inhabit, and that collective identity of physical traits, mental and moral endowments, language, &c., which characterizes all the American races. The same remarks are applicable to all the other human races; but in the present infant state of Ethnographic science, the designation of these primitive centres is a task of equal delicacy and difficulty. I may here observe, that whenever I have ventured an opinion on this question, it has been in favor of the doctrine of *primæval diversities* among men,—an original adaptation of the several races to those varied circumstances of climate and locality, which, while congenial to one are destructive to the other; and subsequent investigations have confirmed me in these views. See *Crania Americana*, p. 3; *Crania Ægyptiaca*, p. 37; *Distinctive Characteristics of the Aboriginal Race of America*, p. 36; *American Journal of Science and Arts*, 1847; and my *Letter to J. R. Bartlett, Esq.*, in vol. ii. of the Transactions of the Ethnological Society of New York.

tic heads will hardly permit them to be admitted into the comparison.

5. The Negro brain is nine cubic inches less than the Teutonic, and three cubic inches larger than the ancient Egyptian.

6. The largest brain in the series is that of a Dutch gentleman, and gives 114 cubic inches; the smallest head is an old Peruvian, of 58 cubic inches; the difference between these two extremes is no less than 56 cubic inches.

7. The brain of the Australian and Hottentot falls far below the Negro, and measures precisely the same as the ancient Peruvian.

8. This extended series of measurements fully confirms the fact stated by me in the Crania Americana, that the various artificial modes of distorting the cranium, occasion no diminution of its internal capacity, and consequently do not affect the size of the brain.

ART. XXVII.—*Remarks on the Aneroid Barometer;* by Professor J. LOVERING of Harvard University.

MOST of the scientific journals of Europe and America have published descriptions of the new French barometer, as it is called. For the construction of the instrument and the history of its invention I may refer to them, particularly to that contained in this Journal, September, 1849.

The two ordinary statical ways of measuring forces are, 1st, by means of gravity, and 2d, by elasticity. Our common balances to measure weight employ either the gravity of a known counterpoise or the elasticity of a spring. In like manner the weight of a column of the atmosphere is determined when we know the height of a similar column of some known fluid which it is able to support or the elasticity of some familiar substance with which it is in equilibrium. The barometer with which all have long been familiar employs the first method. The aneroid barometer, which, as its name implies, excludes all liquids from its construction, is based on the last principle, viz., that of measuring weight by elasticity.

This new instrument is already manufactured in large numbers in France and Great Britain. Its adoption is recommended on the ground of accuracy as well as its great strength and compactness. Barometers are now extensively used, not only for tracing out the grand laws of meteorology, but also as a practical guide to the mariner to forewarn him of approaching storms, and an indispensable instrument of research to the physical geographer and geologist. It is highly important that the mineralogist, the

navigator and the student of general science should know what degree of accuracy may be claimed for the new barometer and how far they are allowed to trust themselves to its indications. With the hope of assisting those who desire to form an opinion on this subject, I present the following experiments and observations, undertaken originally at the suggestion of Prof. A. D. Bache, Superintendent of the U. S. Coast Survey. The instrument employed in this research was furnished by Prof. Bache, and bears the mark 1265, Lerebours and Secretan, Paris.

A series of experiments was first made with this aneroid barometer to determine the whole range of the instrument. For this purpose, it was placed first under the receiver of an exhausting pump, and afterwards under the receiver of a condensing engine. In this way, it was found capable of indicating a change of atmospheric pressure which would move the column of mercury in a common barometer from about twenty inches up to thirty-one inches. From the nature of its construction, the index cannot go beyond the point which corresponds to twenty inches of the mercurial barometer on one side, or that which corresponds to thirty-one inches of the same on the other. How accurately its march between these limits agrees with that of the mercurial barometer will appear from an examination of Table I. The pressure of the air in the receiver of the pump was obtained from the mercurial pump-gauge, which was supplied with common mercury and corrected for level and capillarity. This table shews that, while the index of the aneroid barometer is able to move, it moves farther than the column of mercury under the same change of atmospheric pressure. As it approaches its lower limit, however, it will begin of course to be restrained in the amplitude of its motion, until, at length, the difference between the two instruments changes its sign. It is obvious that, in the particular instrument examined at least, and for long ranges, similar changes of pressure are not marked by equal quantities of motion in the index in all parts of the scale. This might be expected in an instrument where no consideration is given to the distinction between potential and apparent leverage. Besides this which may be called the instrumental error, there is an irregularity in the motion of the index, arising from friction, bending, or some other cause, which would interfere seriously with the accuracy of its indications even if the arc over which the index moves were so graduated as to eliminate the instrumental error.

At the meeting, in 1848, of the British Association for the Advancement of Science, it was stated by Mr. Lloyd that one of his friends had made a similar experiment to that I have described, and that the indications of the aneroid barometer corresponded to those of the pump-gauge to within ·01 of an inch. Such is the statement in the London Atheneum, although I find no mention

made of the subject in the Report of the Association for that year. As the reader is not informed to what amount of diminished pressure the aneroid barometer was subjected in this case, and whether the difference above mentioned was the result of a single observation or the mean residuum of many, he is not able to decide how far the experiments to which Mr. Lloyd refers are at variance with those here published. I cannot say how much of the error manifested in my comparison of the two barometers is fairly to be charged to the general character of the new barometer, and how much is peculiar to the single instrument with which I experimented. As soon as an opportunity offers, I desire to submit other specimens of the aneroid barometer of English and French construction to the same trial.

My next series of experiments consisted in a comparison of the aneroid barometer, day by day, with the common barometer, under the ordinary changes of atmospheric pressure. The mercurial barometer used for the purpose was made by W. & S. Jones, London, and is the same as that employed by Prof. Farrar in his barometric observations published in Volume III. of the Memoirs of the American Academy, Boston. This instrument is furnished with an adjustment for level, an attached thermometer and a scale of corrections for temperature. This correction as well as that for capillarity has been applied to my observations. In this series of experiments it was necessary to know how much the aneroid barometer was affected by a change of temperature. Only a partial compensation is attempted in the construction of the instrument. An increase of temperature tends to make the air in the reservoir expand in the same way as diminished pressure. But the same increase of temperature, by enlarging the metallic surfaces of the reservoir and increasing its capacity, may sometimes even over-compensate for the increased elasticity of the contained gas. In the instrument which I used the compensation fell short; and the amount of the deficiency was determined by exposing the barometer side by side with a thermometer to a temperature of 32° Fah. and reading the index, and then exposing it to a high temperature (in some instances as high as 140° Fah.) and reading the index once more. The difference of the two readings divided by the difference of the two temperatures was adopted as the correction for a single degree and was applied to each of the observations. The value of this correction as obtained from the mean of five experiments is ·0021 of an inch, with the same sign as in the mercurial barometer. The aneroid barometer in my possession was not provided (as is sometimes the case) with an attached thermometer. A thermometer by the side of it and not under the same case as the air-chest will not indicate the exact temperature of the working parts of the instrument. The slowness with which the index returned to its old mark, after

the barometer had been subjected to excessive heat or cold and was then restored to a medium temperature, manifests the importance of having the thermometer inclosed as the rest of the instrument. The standard of temperature adopted was 55° Fah. to accommodate the scale of the mercurial barometer.

The result of this series of comparisons is contained in Table II. Although the agreement is much closer than with the low ranges, it falls far below the requirements of nice scientific investigations. Mr. David Purdie Thompson in his very recent "Introduction to Meteorology," has the following paragraph. "Upon comparison of indications made with the aneroid barometer—not corrected for the particular temperature—and a very perfect mercurial barometer, given by Mr. Dent, we find that from forty-nine observations made between the 6th of January and 23d of February, 1848, the mean difference was 0·037 of an inch, the *aneroid* being in excess; and from sixty similar observations made with a standard barometer, during December, 1848, and between the 3d and 31st of January, 1849, the mean difference amounted to 0·026 of an inch, the *mercurial* being, in this case, in excess over the aneroid barometer. Combining these observations (109 in number) a mean difference amounting to 0·0025 of an inch is found to exist, the indications of the aneroid being in excess. For general use the instrument is thus shown to be well suited; for the measurement of heights it is peculiarly adapted, from its portability and comparative strength; and for nautical purposes we know of no better instrument."—p. 448.

Now it will be observed that the mean difference in the twenty-eight comparisons of the two barometers which I have given amounts to only ·040 of an inch. So far as can be inferred from the value of the mean differences, the comparisons were as satisfactory as in the first set given by Mr. Thompson. Still the single differences are large; whether larger or smaller than in Mr. Dent's observations I am not able to say, as Mr. Thompson has not given the individual differences. Provision has been made in the construction of the instrument for diminishing the mean difference as we alter the general rate of a chronometer. If the mean difference is eliminated from the comparisons and the remaining differences are placed in a column as in Table II, they manifest by the signs of plus and minus the irregularities of the instrument in small ranges and the errors to be expected from these irregularities in single observations. I have arranged the same observations in Table III, according to the sign and the value of these remaining differences. From the sign of the differences it appears that when the barometers fall the aneroid falls most, and when the barometers rise the aneroid rises most. In other words, the aneroid index moving on either side of the point where it agrees with the mercurial barometer moves too fast.

The experiments with the air-pump indicate the same tendency more unequivocally and to about the same proportional amount. For in these experiments, where the barometer and the pump-gauge were indicating the effect of diminished pressure, the aneroid stood at the lowest point; so that when the elevation of the mercury in the pump-gauge is subtracted from the backward motion of the index in the aneroid the sign is always plus: at least, until the lower limit of range is approached. Although this is the general character of the differences, a nice examination of the observations shows that here as well as in the experiments with the air-pump there are errors and fluctuations which cannot be traced to any law of the instrument, and against which no provision can be made.

Table IV. contains a series of observations made with the view of ascertaining the stability in the levers of the aneroid barometer and the firmness of other parts of the instrument. The instrument was read off before being exposed to diminished pressure: it was then noticed with what fidelity and dispatch the index returned to its original position when the original pressure was restored.

In estimating the merits of the aneroid barometer, it must not be forgotten that it is single observations, indicating momentary changes of the atmospheric pressure, on which the navigator most relies. In some of the hurricanes to which he is exposed, the barometer occasionally sinks so low as to come within the range of the experiments made with the air-pump. And yet here if any where the aneroid barometer finds its appropriate sphere. In meteorology, the barometer is the most important instrument of research. The barometer alone of all the instruments in the hands of the meteorologist is independent of merely local changes and gauges the atmosphere to its upper limit. But the range of atmospheric pressure is so limited, that laborious series of observations, with the nicest barometers that can be constructed, are necessary in order to develop the harmonies of this strangely agitated envelope of our planet. No observer would be willing to risk the value of this long labor by trusting to the new barometer until its peculiarities are better understood than at present. It may possibly happen that a long series of observations which eliminate irregularities of weather will eliminate instrumental irregularities at the same time. The same objections apply with greater force to the application of the aneroid barometer to the measurement of heights above the level of the sea. An elevation of eighty-seven feet depresses the mercury by about ·1 of an inch only; hence a small error in the barometer will entail a large error on the estimated elevation. Moreover, a very long series of observations will, in this case, be generally impracticable. I would suggest one farther consideration. The mercurial barom-

eter is in danger of being broken when exposed to the perils of mountain-travel. In this case, the damage, however great, is known, and no error is introduced into science. Unless the tube is broken, the instrument is so simple in its construction that it is not liable to be injured at all. It is otherwise with the aneroid barometer. To appearance it is stronger than the old barometer and can bear a greater strain without being broken. On the other hand, we can easily foresee that it may be materially injured without attracting the notice of the observer at the time, and in this way may conceal its own infirmities under its apparent strength.

Table I.

1849.	Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected for capillarity and level.	Difference.		Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected, &c.	Difference.
Thermometer not observed. Barometer 29·760.				Thermometer 66. Barometer 29·940.			
Sept. 24.	4.27	4.258	.012+	Sept. 27.	10.42	20.721	10.301−
	7.78	7.673	.107+		10.40	19.338	8.938−
	10.10	15.830	5.730−		10.38	18.236	7.856−
	10 07	16.030	5.960−		10.38	17.294	6.914−
	9·78	10.150	.370−		10.36	16.282	5.922−
	9.44	9 268	.172+		10.30	15.030	4.730−
	8.46	8.216	.244+		10 02	10.140	.120−
	7.52	7.264	.256+		9 60	9.268	.332+
	6.48	6.232	.248+		8.68	8.246	.434+
	5.48	5.240	.240+		7.72	7.224	.496+
	4.45	4.388	.062+		6.79	6.332	.458+
	3 38	3.256	.124+		5.61	5.270	.340+
	2.32	2.214	.106+		4.49	4.208	.282+
					3.50	3 256	.244+
					2.36	2.254	.106+
Thermometer 72·5 Fah. Barometer 29·690.				Thermometer 66·5. Barometer 30·170.			
Sept. 26.	10.13	18.537	8.407−	Sept. 29.	10.63	23.035	12.405−
	10.11	17.294	7.184−		10.59	16.262	5.672+
	10 11	16.382	6.272−		10.23	10.220	.010+
	10.07	15.280	5.210−		9.75	9.328	.422+
	9·75	10.220	.470−		9.02	8.426	.594+
	9.36	9.268	.092+		7.95	7.294	.656+
	8.71	8.316	.394+		6.93	6.332	.598+
	7.67	7.274	.396+		5.80	5.270	.530+
	6 67	6.262	.408+		4.63	4.238	.392+
	5.53	5.120	.410+				
	4.67	4.238	.432+		2.45	2.224	.226+
	3.34	3.206	.134+				
	2.30	2.154	.146+				

Dec. 4. The Aneroid barometer was placed under the receiver of a condensing pump and it was observed that the index only moved forward to 31, which corresponds to 31 of the mercurial barometer.

TABLE II.

1849.	Aneroid corrected for Temperature.	Mercurial corrected for level, capillarity and temperature.	Difference.	Difference after eliminating mean difference of instruments.
Dec. 10	29.932	29.977	.045−	.005−
11	30.089	30.107	.018−	.022+
12	30.439	30.507	.068−	.028−
13	30.267	30.237	.030+	.070+
14	30.122	30.117	.005+	.045+
15	30.378	30.397	.019−	.021+
16	30.148	30.147	.001+	.041+
17	29.870	29.907	.037−	.003+
18	30.327	30.327	.000	.040+
19	30.519	30.537	.018−	.022+
20	29.703	29.787	.084−	.044−
21	30.119	30.127	.008−	.032+
22	30.012	30.067	.055−	.015−
23	29.353	29.447	.094−	.054−
24	29.595	29.667	.072−	.032−
25	29.488	29.597	.109−	.060−
26	30.212	30.310	.098−	.069−
27	30.087	30.160	.073−	.033−
28	30.407	30.447	.040−	.000
29	30.025	30.090	.065−	.025−
30	30.200	30.197	.003+	.043+
31	30.115	30.147	.032−	.008+
1850.				
Jan. 2	30.360	30.407	.047−	.07 −
3	30.156	30.207	.051−	.011−
4	29.890	29.937	.047−	.07 −
5	30.125	30.137	.012−	.028+
6	30.464	30.517	.053−	.013−
7	30.340	30.367	.027−	.013+
Mean,	30.098	30.138		
"		30.098		
Diff'nce.		.040−		

TABLE III.

Observations in Table II, arranged according to the amount and the sign of their differences.		
	29.597	.069−
	30.310	.058−
	29.447	.054−
	29.787	.044−
	30.160	.033−
	29.667	.032−
	30.507	.028−
	30.090	.025−
	30.067	.015−
	30.517	.013−
	30.207	.011−
	30.407	.007−
	29.937	.007−
	29.977	.005−
Mean,	30.048	.029−
	30.237	.070+
	30.117	.045+
	30.197	.043+
	30.147	.041+
	30.327	.040+
	30.127	.032+
	30.137	.028+
	30.537	.022+
	30.107	.022+
	30.397	.021+
	30.367	.013+
	30.147	.008+
	29.907	.003+
Mean,	30.212	.029+
"	30.048	
Difference,	.164	

1849. Sept. 10. The Aneroid stood at 30·39. It was placed under the receiver of an air pump and the atmospheric pressure diminished by 5 inches. When the air was admitted, the index moved forward to 30·35. It rose to 30·375 in two or three minutes. The following table embraces similar experiments with their results.

TABLE IV.

	Original reading of the Aneroid Barometer.	Reading after the air was admitted.	Difference.	Degree of rarefaction as measured by the pump-gauge.		Original reading.	Reading after the air was admitted.	Difference.	Degree of rarefaction.
Sept. 10.	30.390	30.375	.015−	5 inch	Sept. 24	29.760	29.720	.040−	16 inch.
	30.480	30.530	.050+	5 "	26	29.690	29.680	.010−	18 "
	30.375	30.360	.015−	5 "	27	29.940	29.930	.010−	20 "
	30.360	30.460	.100+	9 "	29	30.170	30.050	.120−	22 "
	30.480	30.500	.020+	5 "					
	30.530	30.530	.000	9 "					

ART. XXVIII.—*An account of some Fossil Bones found in Vermont, in making excavations for the Rutland and Burlington Railroad;* by ZADOCK THOMPSON.

IN addition to the benefits derived directly from railroads in the business of travel and transportation, the cause of science and particularly the science of geology is deriving indirectly no small advantage from their construction. The deep cuttings which these works often require, expose the various strata of rocks where they have not been affected by the weather for the examination of the geologist, and the vast excavations in stratified sand and clay, and in the confused beds of drift materials, exhibit not only the relations of these to each other, but frequently disclose organic remains which shed new light upon the early history of our earth.

Only about four years have elapsed since the construction of railroads was commenced in Vermont, and at this time, nearly three hundred miles of railroad are so far completed as to be in use within the state; and, while the excavations for these roads have conduced to a more accurate knowledge of the position, age and lithological character of the rock formations, they have at the same time very unexpectedly disclosed organic remains, which are of much scientific interest and importance. In grading the line of the Rutland and Burlington Railroad, portions of the skeletons of two large animals, both belonging to the class *mammalia*, and to families which no longer exist here in a living state, were found deeply buried in the earth, and the bones were for the most part in a very good state of preservation.

Fossil Elephant.—The Rutland and Burlington Railroad passes over the range of Green Mountains in the township of Mount Holly, at an elevation of 1360 feet above the level of the sea. In the notch through which the railroad passes, and very near the dividing point between the waters which flow westward into Lake Champlain and those which run eastward into Connecticut River, there is a deep deposit of vegetable muck. The cut for the railroad is through this muck-bed. In making it the workmen, to their great astonishment, found an enormous tooth. It was resting upon gravel at the bottom of the muck, which was there about nine feet deep. It was in a very good state of preservation, weighed eight pounds, and measured about eight inches transversely across the crown. It was pronounced by Professor Agassiz to be a *grinder* of an extinct species of elephant. Subsequently, as the excavation was continued, the two tusks and several of the bones of this elephant were found, and it is not improbable that the remaining parts of the skeleton are still buried beneath the same muck-bed.

Fossil Cetacean.—The fossil bones, which it is more particularly the object of this paper to describe, were found on the line of the Rutland and Burlington Railroad in the month of August, 1849, in the township of Charlotte, about twelve miles south of Burlington, and a little more than one mile eastward from the shore of Lake Champlain. In widening a deep and extensive cut through stratified sand and clay, the workmen there struck upon a mass of bones. They were between eight and nine feet below the natural surface of the ground, and were very compactly bedded in fine adhesive blue clay. Little notice was taken of them at first, until some of the overseers, thinking that they observed peculiarities in the form of several of the bones, were induced to commence an examination. They soon found that the bones discovered belonged to the anterior portion of the skeleton of some unknown animal, the head of which had already been broken into fragments by the workmen, and many of the fragments carried away with the earth which had been removed. On carefully removing more of the clay, the vertebræ were found extending in a line obliquely into the bank, and apparently arranged in the order in which they existed in the living animal. These vertebræ were, as was supposed, all taken out, and together with the sternum, fragments of head, ribs, &c., forwarded to Burlington, and by the kindness of Messrs. Jackson and Boardman, engineers on the railroad, were placed in my hands.

Upon a careful examination of these bones, I ascertained that the greater part of the head, all of the teeth, and several vertebræ, ribs, and bones of the limbs, were wanting in order to complete the skeleton. To recover these if possible, I immediately visited the locality; and at this and a subsequent visit, I succeeded in obtaining most of the anterior portion of the head, nine of the teeth, and thirteen additional vertebræ, together with the bones of one forearm, several chevron bones and portions of ribs. My first object being to insure the preservation of the bones, I carefully cleansed them from the adhesive clay, and then saturated them with animal glue.

When I first looked at the bones, I was in doubt whether they belonged to an animal of the cetaceous or saurian family, but my doubt was soon removed by a careful examination of the caudal vertebræ. These I found to have their articulating surfaces convex and rounded in such a manner as to allow of very extensive vertical motion of the tail, and but very little lateral motion. This circumstance plainly indicated that the movements of the animal in the water were effected by means of a horizontal caudal fin, and that it, therefore, belonged to the family of *Cetacea*.

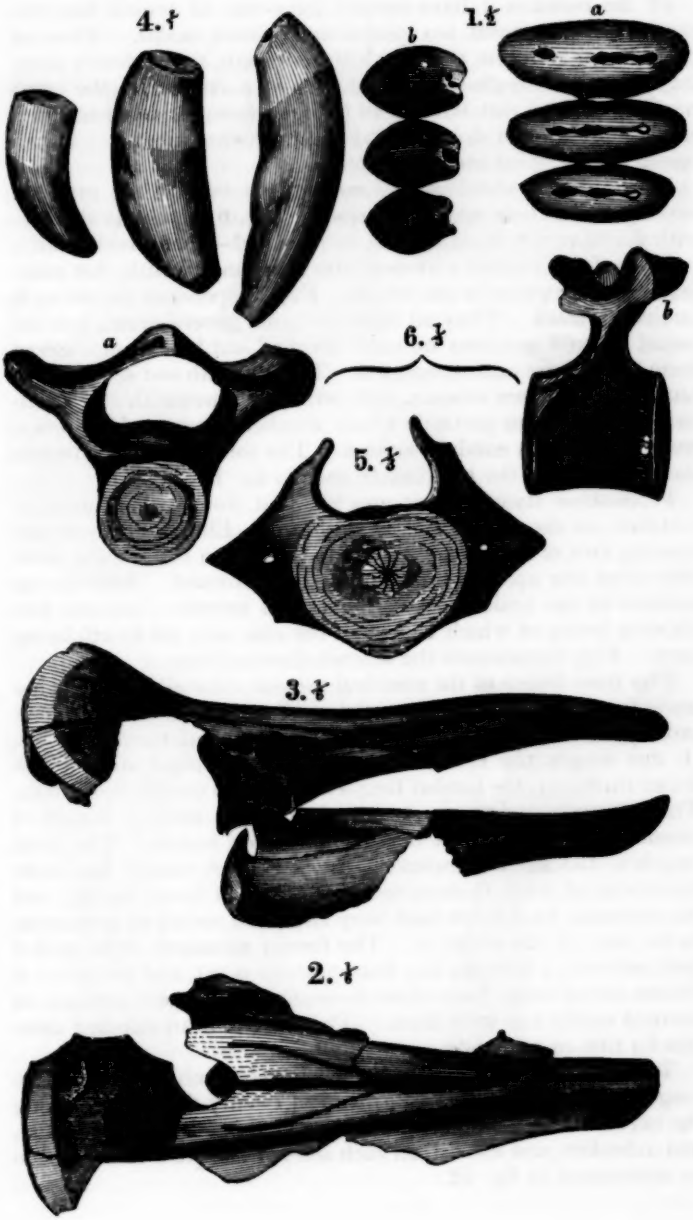
Fig. 1 represents the thirteenth, fourteenth and fifteenth vertebræ of the tail, showing the manner in which they move upon

each other—*a*, as viewed from above—*b*, as seen laterally.—[The fraction after the No. of the figure, denotes the linear proportion of the figure to the object which it represents.]

But, if there had still remained any doubt with regard to the general character of the animal, it would have been entirely removed, when I succeeded afterwards in reconstructing out of the fragments of bones which I had procured, so much of the upper anterior portion of the head, as to exhibit distinctly its *spiracles*, or blow-holes, showing unequivocally that it belonged to the Whale family. My next object was to ascertain, if possible, whether it belonged to an extinct, or to a living species or genus of this family. By a careful examination of Cuvier's great work on Fossil Bones, I became satisfied that, in the osteology of the head, it bore a strong resemblance to a small arctic cetacean, called the *Beluga*, or white whale, (*Delphinus leucas, Cuv. Oss. Foss.*, v, p. 297, pl. xxii, fig. 5 and 6, Paris ed., 1825,) and that it therefore belonged rather to the living than to the extinct types; and this opinion was confirmed by Prof. Agassiz, to whose unrivaled skill and kind assistance in the investigation of these fossils I am deeply indebted.

The head of the skeleton, as already remarked, was broken into a great number of pieces, but enough of these have been recovered and matched to determine very nearly the form and entire length of the head and of one side of the lower jaw, and of its symphysis with the other side. The fragments of the anterior portion of the upper jaw were found and matched, with the exception of so much of the maxillary bone as formed the alveolar margin of the left side. The alveolar margin on the right side measures 6·85 inches in length and contains eight alveoli. In the corresponding side of the lower jaw there are seven alveoli in a length of 5·5 inches, the alveolar margin extending three inches farther backward, but not perforated for teeth. Fig. 2 represents the head, viewed from above, so far as reconstructed, and fig. 3, a side view with the lower jaw dropped a little below its true place.

It appears, from what has been said above, that the animal had seven teeth in the lower jaw and eight in the upper, on each side, making thirty teeth in the whole. The teeth are all of one kind, being conical with flat or rounded crowns, and their substance is very dense and firm. They vary in length from one to nearly two inches, with a diameter of about half an inch. Fig. 4 represents their different forms. Only nine of the teeth have been recovered, and none of these were in their places in the jaws when I obtained them; but that they were in their places up to the time the bones were first discovered by the workmen, appears evident from the fact, that, while every other cavity in the bones was filled with clay, the alveoli were all empty.


4. ½
1. ½
a
b
b
a
6. ½
5. ½
3. ½
2. ½

Of the vertebræ I have secured forty-one, of which four are cervical, eleven dorsal, ten lumbar and sixteen caudal. Three of the cervical vertebræ, the first, fifth and sixth, are evidently missing, which, with those obtained, would make *seven*, the usual number. These vertebræ are all free, not being soldered together as in the common dolphin and some other cetaceans. Fig. 5 represents the third cervical vertebra.

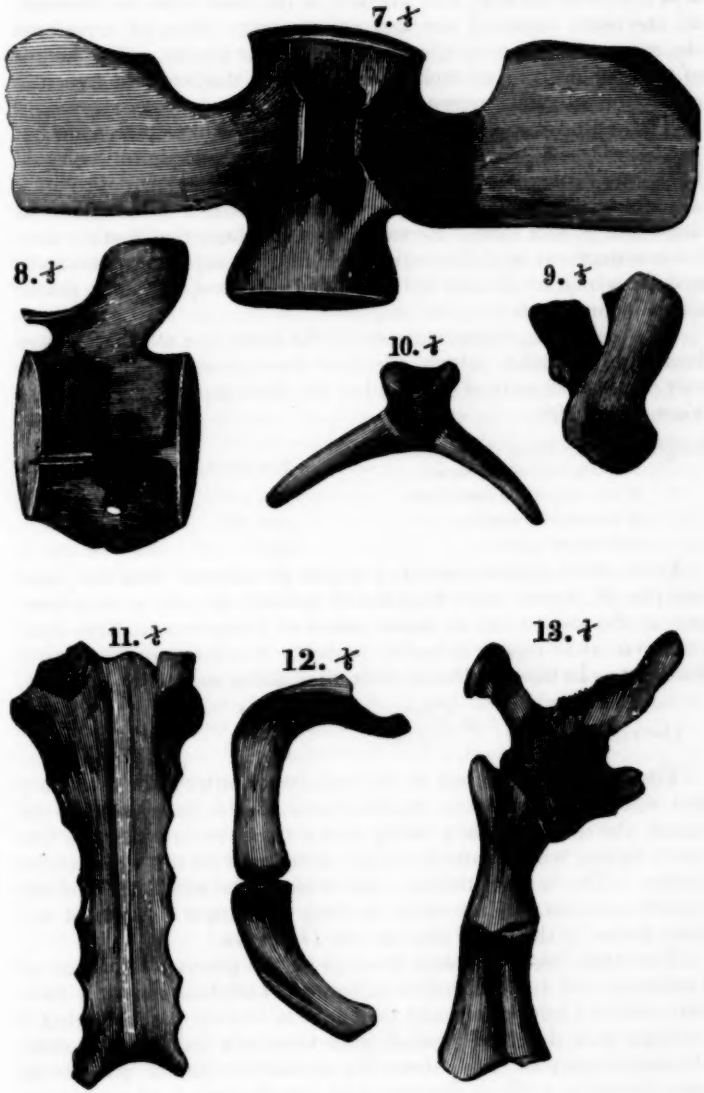
Of the dorsal vertebræ, the second and twelfth are missing, making their whole number thirteen. Fig. 6 represents the seventh dorsal vertebra—*a*, as seen from behind—*b*, as seen laterally.

Two of the lumbar vertebræ, the sixth and twelfth, are missing, making twelve in the whole. Fig. 7 represents the seventh lumbar vertebra. They all have the same general form, but the lateral winged processes are more decayed and broken in some of them than in the one represented. The eleventh and seventeenth caudal vertebræ are missing, and perhaps a nineteenth and twentieth, making their probable whole number twenty. Fig. 8 represents the fourth caudal vertebra. The form of those towards the extremity of the tail may be seen in fig. 1.

From these statements it appears, that the whole number of vertebræ in the skeleton was fifty-two. Eleven of these are missing, two of which are known to have been taken away after they were dug up, and may perhaps be recovered. Articulating surfaces on the under sides of the caudal vertebræ, indicate five chevron bones, of which I have all but one, only the fourth being gone. Fig. 9 represents the second chevron bone.

The total length of the vertebral column, (due allowance being made for the eleven missing vertebræ, but none for intervertebral cartilages,) is just ten feet, or one hundred and twenty inches. Of this length the cervical vertebræ occupy eight inches, the dorsal thirty-six, the lumbar forty-two, and the caudal thirty-four. The lumbar vertebræ are largest, having an average length of about four inches and a diameter of three inches. The total length of the animal, including the head and caudal fin, must have been at least thirteen feet. The *hyoid* bone, fig. 10, and the *sternum*, fig. 11, are both very large and strong in proportion to the size of the skeleton. The former measures eight and a half inches in a straight line from point to point, and the latter is fifteen inches long, from three to seven inches wide, and on an average nearly one inch thick. There are four articulating cavities for ribs on each side.

The ribs are considerably decayed and much broken. The longest rib, in one piece, measures just twenty-four inches along the curve. The ribs which form the anterior pair are very strong, and unbroken, and consist, on each side, of two parts of solid bone as represented in fig. 12.


7. ½
8. ½
9. ½
10. ½
11. ½
12. ½
13. ½

Of the limbs, the two scapulæ, one humerus, and the two forearm bones on one side, and the ulna of the other side, are secured; all the other bones of the fins are missing. Fig. 13 represents the recovered bones of the left fin, in their places. The height of the scapula is seven inches, the length of the humerus five, and of the forearm four inches.

There are several of the recovered bones, whose places are not yet ascertained. Some of these may be appendages to the hyoid bone and others may belong to a rudimentary pelvis. Professor Agassiz who has manifested, as already stated, a deep interest in these fossils, has kindly consented to give them that further careful investigation, and illustration, which their importance demands, and for which he is most ably qualified; I have, therefore, placed them in his hands for that purpose.

The following measurements of the head, are all that I have been able to make, which admit of direct comparison with Cuvier's measurements of the head of the Beluga, *D. leucas*. (Oss. Foss., v, p. 302.)

	Fossil.	*D. leucas.*
Length of the head from the occipital condyles to the end of the snout,	21·2 inches,	·532 m. = 20·9 inc.
" of one side of the lower jaw,	16·5 "	·408 " = 16·5 "
" of the alveolar margin, "	8·2 "	·198 " = 7·8 "
" of the symphysis "	3·1 "	·080 " = 3·1 "

From these measurements it might be inferred that the *fossil* and the *D. leucas* were identical in species, as well as in genus; but, at the same time, so many points of disagreement have been observed, as to render it highly probable that they are specifically different. In the number of teeth, they differ, as expressed below.

	Fossil.	*D. leucas.*
Dental Formulæ	$\frac{8}{7}\ \frac{8}{7} = 30$:	$\frac{9}{9}\ \frac{9}{9} = 36$.

They also differ much in the relative width of the maxillary and intermaxillary bones, as developed on the upper side of the snout, the intermaxillary being wider than the maxillary in Cuvier's figure, while in the fossil, the latter is twice the width of the former. The lines of the face appear also to be straighter, and the coronal process less elevated, making the upper portion of the head flatter in the *fossil* than in the *D. leucas*.

That this fossil cetacean belongs to the genus *Delphinus* of Linnæus, and to Lacepede's subgenus, *Delphinapterus*, I have little doubt; but, as already stated, it is highly probable that it belongs to a different species from Gmelin's *leucas*. I would, therefore, propose *Delphinus Vermontanus* for its provisional specific name, until its identity with the *D. leucas*, or some other known species, shall be established.

The locality, where these fossil bones were found, is situated a little more than one mile to the eastward of lake Champlain, and 60 feet above the mean level of the lake, as ascertained by

the railroad survey. The mean height of the lake is 90 feet above the level of the sea, making the height of the point, where the fossils were imbedded, 150 feet above the sea. The geological formation, in which they were found, is very clearly characterized. It belongs to that portion of the Post-tertiary, which has sometimes been denominated the *Pleistocene* formation. This formation extends along the whole length of lake Champlain, and throughout the valley of the St. Lawrence. On the east side of the lake, in Vermont, it frequently attains a width of several miles, and, in places, exceeds 100 feet in depth. It consists, for the most part, of regularly stratified clay and sand, resting upon the Champlain rocks, or upon unstratified drift, and portions of it abound in marine bivalve fossil shells. These shells are of several species, nearly, or quite all of which are now found in a living state, on the Atlantic shores of New England: and it is common to find them with their valves united, with their epidermis undisturbed, and buried in such a position as to show, unequivocally, that they lived, propagated and died, in the places where they are found. The most abundant species is the *Sanguinolaria fusca.* The *Mya arenaria*, *Saxicava rugosa* and *Mytilus edulis* are quite common. Some other species are occasionally found.

The cut for the railroad, in which these fossil bones were obtained, is nearly half a mile in length, extending from north to south, and its greatest depth is about eighteen feet. The depth of the cut, at the place where the skeleton was found, is ten feet. About four feet of this depth, reckoning from the natural surface of the ground, consists of sand, showing no signs of stratification. Next below this is a mixture of sand and clay, which is regularly and distinctly stratified, for a depth of two and a half feet, below which is a vast bed of fine blue clay, in which I observed no signs of stratification, and which appears to have been, previous to the deposit of the sand and clay above it, a kind of quagmire. In the lower part of the stratified sand and clay, and nearly in contact with the upper surface of the blue clay, the shells of *Sanguinolaria fusca* and *Mytilus edulis* were exceedingly numerous. Below these, imbedded in the blue clay, were the *fossil bones.* The head of the skeleton was towards the northwest and lay lowest, while the body and tail extended towards the southeast. The highest part of the skeleton was about eighteen inches below the upper surface of the blue clay, or eight feet below the natural surface of the ground. In the clay, mingled with the bones, I found a number of specimens of *Saxicava rugosa* and two or three of *Nucula;* and I also found in it such indications of vegetable remains as to leave little doubt that this clay bed, once and for a long time, constituted a salt marsh, with rushes and grasses on the shore of the Pleistocene sea that then occupied the valley of lake Champlain.

Burlington, Vt., Jan. 1, 1850.

ART. XXIX.—*Abstract of a Meteorological Journal, kept at Marietta, Ohio, for the year* 1849, Lat. 39° 25′, Long. 4° 28′ west of Washington city; by S. P. HILDRETH, M.D.

MONTHS.	THERMOMETER.							BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	In. and 100ths Rain and melted snow.	Prevailing winds.	Maximum.	Minimum.	Range.
January, - -	30·46	59	6	9	22	4·09	w. & s. w.	30·10	29·25	·85
February, -	30·21	68	–2	12	16	2·58	w. s. w. & s. e.	29·85	29·20	·65
March, - -	45·04	72	21	14	17	4·37	s. s. w. & s. e.	29·60	28·88	·72
April, - -	50·57	84	21	20	10	2·50	s. w. & s. e.	29·60	28·95	·65
May, - -	61·40	86	38	20	11	5·92	s. & s. e.	29·70	29·10	·60
June, - -	71·33	89	50	21	9	4·42	s. & s. w.	29·65	29·20	·45
July, - -	72·20	89	48	25	6	1·21	s. & s. e.	29·70	29·30	·40
August, -	69·61	86	52	22	9	3·50	s., s. & e.	29·50	29·15	·35
September, -	62·57	84	40	27	3	2·63	s., n. & s. e.	29·75	28·90	·85
October, - -	53·15	74	30	19	12	3·92	s. w. & w.	29·70	28·88	·82
November, -	47·25	78	20	25	5	2·58	s. s. e. & w.	29·58	29·10	·48
December, -	31·33	55	9	12	19	5·17	w., n. & s. e.	30·00	28·95	1·05
Mean for year,	52·09					43·18				

THE mean temperature for the year 1849, is fifty-two degrees and nine hundredths, (52·09), being somewhat below the average temperature for this place, and was occasioned by the low grade of the summer months. It goes, however, to prove that the mean heat for this locality lies between fifty-two and fifty-three degrees of Fahrenheit.

The amount of rain and melted snow for the year is forty-two inches and eighty-nine hundredths, being over an inch less than in 1848, and ten inches less than in 1847. The rain has been very equally distributed through the year, affording an abundant supply for the crops generally, although some locations suffered from drought in July, injuring the corn crop considerably.

The past year has been marked by no great excesses in temperature. The cold in January and February, for a portion of the time, was quite severe; sinking the mercury on the 19th of the latter month, to two degrees below zero. It caused a great deal of floating ice in the Ohio river, so as to stop the progress of steamboats for a short time, but did not at any period freeze over the river so as to afford travellers a passage on the ice. The Muskingum from the slack-water improvements was closed for some weeks. The mean for the winter months is 34° 25′, being about two degrees less than that of 1848. Of snow, there fell about fourteen inches on six different periods; the largest amount at one time being six inches.

The mean of the spring months is 52° 33′; being rather below that of the previous year. Spring frosts continued to harass us as late as May, while on the 15th, 16th, and 17th of April, the frost was severe, sinking the temperature to 23°. It happened after a week of quite warm weather, and at a time when the pear, peach and plum were in bloom—killing nearly all these fruits. The apple did not bloom until the 27th of the month, but the germs were so much injured that the crop was almost entirely destroyed. One of the serious evils attached to our climate, is the frequent occurrence of late spring frosts at a time when fruit trees are most liable to injury. The beginning of May was marked by excessive rains, there falling nearly six inches during that month.

The mean temperature of the summer months is seventy-one degrees and five hundredths, which is about two degrees above that of 1848, and exactly that of 1846.

At two o'clock, on the morning of the 15th of June, a tremendous storm of electric fluid passed over this region, continuing for nearly two hours to discharge a continual stream of lightning, accompanied by terrific peals of thunder; several dwelling houses were struck, and trees demolished in the town. It ran along the telegraph wires into the office at Marietta, and ruined the magnetic machine. There fell two inches of rain, attended with little or no wind. The latter part of June was quite wet, rain falling almost daily, with a hot moist atmosphere, accompanied near the rivers with fogs. This state of the weather has been noticed by agriculturalists, as very injurious to the wheat crops, falling as it does at a time when the grain is forming, about the middle or last of June, producing a mildew or rust on the head and straw, and thus blighting the berry. The rust or blight this year prevailed throughout all the southern portions of Ohio, extending into Indiana and Illinois; while the northern districts of these states, being later in ripening, suffered but little. The color of this parasite was that of a bright iron rust, and so abundant that a cloud of dust arose from the straw as it fell before the progress of the reapers, covering the garments of the workmen with a red powder, as if colored by a dye. The same red fungus attacked the leaves of the common blackberry bushes, near the wheat, and was seen on the earth in divers places in the fields and in some gardens. Its effects were ruinous to the wheat crops, shrinking the grain in the most favored fields fifteen or twenty pounds in the bushel, destroying its farina so that merchantable flour could not be made from it, and causing a loss to the farming interest of several millions of dollars. Thousands of acres were entirely ruined and not harvested at all. Rye suffered more than wheat, being somewhat earlier in its growth. Grapes were attacked in the same manner, the mould on them being white, attaching itself to the stems, causing the fruit to blight

and fall to the ground. Potatoes were generally good and free from "the rot." Indian corn was a fair yield, while the hay crop was never better. Our soil and climate are so constituted that if one of the staples fails, some other will supply its place; and it is not probable we shall suffer from famine, as they do in many parts of the earth.

The mean of the autumnal months is fifty-four degrees and thirty-two hundredths, being nearly five degrees warmer than that of 1848. Frost did not materially injure vegetation and garden plants until the first of November, when the cold destroyed the bloom of the Dahlia.

Floral Calendar.—March 7, White maple in bloom; 8th, Robin appears; 17, Hepatica triloba in bloom. Red elm, garden crocus.

April 4th, Apricot, Sanguinaria canadensis; 7th, Peach; 8th, Sugar tree quite green on side-hills; 11th, Green gage and cherry in bloom; 12, Pear; 15th, thermometer at 24° this morning, froze hard; 16th, thermometer 23°, some snow fell; the fruit blossoms to a large extent killed, and early garden vegetables; 25th, Tulip in bloom; 27th, Apple; Late cherry; 29th, Judas tree and Service berry.

May 1st, Ranunculus; 2d, Quince tree; 5th, Black haw; 7th, Cornus florida; 11th, Frost on fences back of town; 19th, frost on boards; 24th, Locust tree; 29th, Hudson strawberry ripe.

June 3d, Early peas fit for table; 15th, Russian cucumber, raised in open air; 19th, thermometer 121° in the sun's rays at 2 P. M.; 22d, the Rust noticed on the wheat, but began as early as the 15th in some places.

July 2d, Wheat harvest begins; 3d, Catalpa in bloom.

Marietta, January 23, 1850.

ART. XXX.—*Chemical Examinations of the Waters of some of the Mineral Springs of Canada;* by T. S. HUNT, Chemist and Mineralogist to the Geological Commission of Canada.

IN the course of my official duties it has devolved upon me to examine the various mineral waters of the province and to submit the more important of them to accurate analyses. The first part of the results of these inquiries have already appeared in the Report of Progress for 1847, 1848, which was submitted to his excellency the Governor General on the 1st of May, 1849, from which I extract the analyses that follow. Some remarks as to the mode of collecting the waters may not be out of place here, as showing the precautions taken to prevent errors and to transport the waters unchanged to the place of analysis. Unless other-

wise stated, they were always collected by myself from the spring, and put into large glass jars, holding about one hundred pounds; these were nearly filled, and being carefully stopped, the mouths were secured by a lute, which entirely excluded air and prevented the escape of gases. For the determination of the gases, the processes directed by Fresenius, in his admirable treatise, were employed; they consist in directly fixing upon the spot the carbonic acid gas by ammonio-chlorid of calcium, and the sulphuretted hydrogen by a solution of chlorid of arsenic. Carefully measured portions of the water being placed in bottles with these substances, the bottles were tightly sealed, and could thus be preserved until they were brought to the place of analysis.

In stating the composition of the waters, I shall first give the quantity of bases, acids and radicals in a thousand parts, and then in accordance with the general custom, shew how these may be united to form saline combinations; in following this course I have conformed to the general practice of chemists, rather because the results are more intelligible to the unscientific, and at the same time more readily compared with those of other analysts, than because the compounds thus calculated can be supposed to represent the real constitution of the water; for in the present state of our knowledge, we must, I think, be led to adopt the idea of a partition of bases among the different radicals, so that the bromine in a saline water instead of being, as it is here represented, in conformity with general custom, combined as a bromid of magnesium, is divided between the four metals usually present, in proportions which we have not yet the means of determining.

The analyses were performed upon weighed portions of water in preference to using measures; and the weights, including the specific gravities, were determined by a delicate balance made to order by Deleuil of Paris, and sensible to the demi-milligramme, when loaded with two hundred grammes.

The Caledonia Springs.—These springs which are well known as a place of resort during the warm season, are situated a few miles south of the Ottawa River, about forty miles from Montreal; the fountains which are four in number rise through strata of post-pliocene clay which overlie a rock equivalent to the Trenton limestone. Three of them, known as the Gas Spring, the Saline Spring, and the White Sulphur Spring, are situated within a distance of four or five rods, and the mouths of the latter two are not more than four feet apart. The fourth, known as the Intermitting Spring, is situated about two miles distant, and is much more saline than the others. The first three are alkaline, the sulphur spring strongly so, while the fourth contains in solution a great quantity of earthy chlorids.

None of these waters are what are called "acidulous saline," a character which is due to the presence of large quantities of car-

bonic acid, the quantity of this acid found, being in no case more than is required to form bicarbonates with the bases present.

I. *The Gas Spring.*—The waters of this spring were collected on the 27th of September, 1847. The temperature of the air being 61·7° Fahrenheit, that of the spring was 44·4. The discharge was ascertained by careful measurement to be four gallons per minute, a quantity which is little subject to variation. The water in the well is kept in constant agitation by the escape of carburetted hydrogen gas, which is evolved in considerable quantity. It was roughly estimated at the time, to be three hundred cubic inches a minute, but the discharge as I was informed, is often much more abundant.

The specific gravity of the water was found to be 1006·2. It is pleasantly saline to the taste, but not at all bitter; by exposure to the air it gradually deposits a white sediment of earthy carbonates. Its reaction is distinctly alkaline to test papers.

The examination of the unconcentrated water shewed the presence of chlorine, calcium and magnesium, but when the liquid is concentrated by boiling, these bases are wholly precipitated as carbonates, and the clear liquid is alkaline, yielding with a solution of chlorid of barium, a copious precipitate of carbonate which is dissolved by hydrochloric acid, leaving only a small quantity of sulphate of baryta. The alkaline liquid being evaporated to dryness, and the residue digested with alcohol, the solution gave evidence of the presence of both bromine and iodine; the saline residue was found to consist of salts of sodium with a small portion of chlorid of potassium. The precipitate of earthy carbonates contained traces of alumina, iron and manganese. On evaporating to dryness a quantity of the water with an acid, and treating the residue with water, a portion of silica was obtained.

The modes by which the quantities of chlorine, sulphuric acid, calcium, magnesium, sodium and potassium were obtained, need no particular description. The sketch of the plan of analyses here given, will be sufficient to show the processes adopted throughout the research, except that where the waters contained chlorids of calcium and magnesium, the amount of these bases was determined first upon one thousand grammes of the water evaporated with an acid, and then the same quantity having been boiled with the addition of distilled water until all the earthy salts were precipitated, the respective amounts of the calcium and magnesium, both in the precipitate and filtrate, were determined, and those in the latter, regarded as corresponding to the chlorids and sulphates of those bases, in the recent water. The alkalies were separated by successive treatment with baryta and carbonate of ammonia, and the amount of potassium in the mixed chlorids was then determined by converting them into the platino-chlorids, and separating the sodium salt by alcohol.

The bromine and iodine were determined by evaporating fifty pounds of the water to a small bulk, separating the earthy precipitate, and finally evaporating the residue to dryness. This was treated with alcohol of sp. gr. ·835 until all traces of iodids and bromids were removed. The alcoholic solution was then evaporated to dryness, and the treatment renewed with alcohol of ·820; this process was repeated a third time, having previously ignited the residue to destroy any organic matters, and the solution being again evaporated to dryness, was dissolved in water, and the amount of iodine determined after the admirable method of Lassaigne, which consists in precipitating it as an iodid of palladium.

The bromids and chlorids remaining in the solution, were decomposed by a solution of nitrate of silver, and the mixed precipitate of chlorid and bromid of silver, after being fused and carefully weighed, was submitted in a state of fusion to the action of a current of dry chlorine gas, until the whole was converted into chlorid; from the loss, the amount of bromine was deduced by calculation.

The total amount of carbonic acid was determined by mixing measured portions of the water at the source, with caustic ammonia and a solution of chlorid of calcium; the proportion of carbonic acid in the precipitate thus obtained, was determined in the usual manner. The amount of carbonic acid required by those bases which were known to exist as carbonates in the water, was then deducted. The quantity of carbonate of soda was calculated from the excess of sodium over that required for the saturation of the chlorine, bromine, iodine and sulphuric acid, controlled by the amount of carbonate of baryta obtained by treating a solution of the solid residue of 1000 grammes of the water with chlorid of barium; the two results closely agreeing.

1000 parts of the water of the Gas Spring gave—

Chlorine,	4·242810
Bromine,	·011730
Iodine,	·000461
Sulphuric acid (SO^3),	·002400
Soda,	3·726400
Potash,	·022100
Lime,	·082880
Magnesia,	·254600
Alumina,	·004400
Silica,	·031000
Iron and manganese,	traces,
Carbonic acid,	·705000

These may be combined to form the following compounds—

Chlorid of sodium,	6·967500
" of potassium,	·030940

Bromid of sodium,	·015077
Iodid of sodium,	·000530
Sulphate of potash,	·005280
Carbonate of soda,	·048570
" of lime,	·148000
" of magnesia,	·526200
" of iron and manganese,	traces,
Alumina,	·004400
Silica,	·031000
Carbonic acid,	·349000
Water,	991·873503
	1000·000000

Saline ingredients in 1000 parts, 7·7775.
Carbonic acid in 100 cubic inches, 17·5.

II. *The Saline Spring.*—The spring thus named, is very similar to the last, but in reality less strongly saline. Its temperature was 45° F., that of the air being at the same time 60° F. The specific gravity 1005·824. Its reaction is more strongly alkaline, but otherwise the results of its qualitative examination are similar to those given under the head of the "Gas Spring." It contains no sulphuretted hydrogen whatever; some few bubbles of carburetted hydrogen are evolved, but the quantity is very small. The discharge from this spring is about ten gallons per minute.

1000 parts of the water gave—

Chlorine,	3·93830
Bromine,	·01317
Iodine,	·00123
Sulphuric acid (SO^3)	·00220
Soda,	3·52246
Potash,	·04100
Lime,	·06580
Magnesia,	·25020
Silica,	·04250
Alumina, iron and manganese,	traces,
Carbonic acid,	·64800

These may be combined in the following manner:—

Chlorid of sodium,	6·44090
" of potassium,	·02960
Bromid of sodium,	·01696
Iodid of sodium,	·00146
Sulphate of potash,	·00480
Cabonate of soda,	·17620
" of lime,	·11750
" of magnesia,	·51724

Carbonate of iron and manganese, Alumina,	traces,
Silica,	·04250
Carbonic acid,	·29200
Water,	992·36084
	1000·00000

The amount of solid matter in 1000 parts of the water is by calculation 7·347; experiment gave 7·280, which is a close approximation. The carbonate of magnesia loses a part of its carbonic acid during the evaporation, and exists in the residue as a basic carbonate; hence the slight deficiency in the result of experiment.

The quantity of carbonic acid, above what is represented as combined with the bases, equals 14·7 cubic inches in 100 cubic inches of the water.

III. *The Sulphur Spring.*—This spring is situated very near to the last; the openings of the two wells being not more than four feet apart. Although it bears the name of a sulphur water, its claim to that title is very small. It has a feebly sulphurous taste and odor, and darkens slightly salts of lead and silver, but the quantity of sulphur existing either as sulphuretted hydrogen or as alkaline sulphuret is very inconsiderable, and cannot be quantitatively estimated by the ordinary processes.

Several bottles of the water were mixed with a solution of arsenic at the spring, but the precipitate of sulphuret of arsenic was scarcely perceptible; the quantity of the sulphuretted hydrogen was not equal to a cubic inch to a gallon. It is still, however sufficient to impart medicinal powers to the water, for the efficacy of this spring over all the others in rheumatic and cutaneous affections is well attested. According to Dr. Stirling, who has been for many years a resident at the springs, and is a careful observer, the water was formerly much more sulphurous than at present; a thing not at all improbable, as it is well known that springs often change their character materially in the course of a few years.

The supply from this spring is apparently about the same as that of the "Gas Spring;" its waters flow into the same reservoir as those of the saline springs, and the two are used for hot baths. The mixture, after being heated for use, is without any odor of sulphur.

The temperature of the spring was found to be 46° F., that of the air being 60° F. The specific gravity of the water at 60° F. is 1003·7; its reaction is strongly alkaline, and the results of its qualitative examination show that it closely resembled the two preceding waters, except that only traces of iodine were detected in it.

1000 parts of the water of the sulphur spring gave:—

Chlorine,	2·12500
Bromine,	·00781
Iodine,	traces,
Sulphuric acid,	·01030
Potash,	·01450
Soda,	2·12370
Lime,	·11760
Magnesia,	·14230
Iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·59000

These combined in the usual manner, give as the composition of 1000 parts of the water:—

Chlorid of sodium,	3·84300
" of potassium,	·02300
Bromid of sodium,	·01004
Iodid of sodium,	traces,
Sulphate of soda,	·01833
Carbonate of soda,	·45580
" of lime,	·21000
" of magnesia,	·29400
" of iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·14100
Water,	994·91818
	1000·00000

The amount of solid matters in 1000 parts of the water is 4·9406.

The quantity of carbonic acid over that required to form neutral carbonates, would in a gaseous state equal 7·2 cubic inches in 100 of the water. The amount required to form the above carbonates is ·449, and an equal quantity of carbonic acid would be necessary to enable them to exist as bicarbonates, a condition in which these earthy bases are generally regarded as being dissolved in mineral waters. The whole of these alkaline waters have shown, it will be observed, a deficiency in the quantity of carbonic acid, and this is particularly marked in this last and most strongly alkaline of them all. This apparent difficulty is at once explained by the fact that the whole, or a part of the carbonate of magnesia, exists in the form of a double carbonate of soda and magnesia, a compound which is readily soluble in water and much more permanent than the bicarbonate

The large amount of silica which it contains, is an interesting peculiarity, and naturally connects itself with the strongly alkaline character of the water. As silica is capable of decomposing a solution of carbonate of soda, it is probable that a portion of the soda must really exist in the condition of a silicate. From the uncertainty which still remains as to the composition of these soluble silicates, it is impossible to calculate the portion of the soda which should be deducted from that represented as existing as carbonate, but an indirect experiment throws some light upon the question. 1000 grammes of the water were evaporated to perfect dryness, to render all the magnesia insoluble. The residue being then dissolved in distilled water, was mixed with a solution of chlorid of barium, and yielded a precipitate of carbonate, with a little sulphate, which contained an amount of carbonic acid corresponding to ·2540 of carbonate of soda, while the excess of soda above that required for saturating the chlorine, bromine and sulphuric acid, equalled ·4558 parts of carbonate. The difference ·2018 corresponds to ·1179 of pure soda, which may be regarded as forming a silicate with the ·0840 of silica. With our imperfect knowledge of silicates, especially the soluble ones, it is obviously useless to speculate farther upon the mode of combination in which these substances exist.*

IV. *The Intermitting Spring.*—This spring has been already described as situated about two miles distant from the others. It rises out of a bank of clay near the edge of a brook; a well has been sunk nearly thirty feet through the clay, and the water rises near to the surface. It is kept in almost constant agitation by the evolution of large quantities of carburetted hydrogen gas; the water from this cause, is kept constantly turbid by the quantity of clay diffused through it, and it is only after being allowed to stand for several hours in a quiet place, that it becomes transparent. The discharge of gas is not regular, some minutes often elapsing, during which only a few bubbles escape from time to time, after which a copious evolution occurs for a few moments, followed by another period of quiescence; from this peculiarity it is named the intermitting spring.

The temperature was found to be 50° F. at the bottom of the well; that of the air being 61°. The amount of water furnished by the spring could not be easily determined, as part of it escapes through the bank, but it is not large. At the time of my visit, the recent rains had diluted the spring with a good deal of surface

* Since my report was published, I find that Mr. O. Henry in his fine researches upon the sulphurous alkaline waters of the Pyrenees, has already shown that the soda generally regarded as existing in them as carbonate, is really in a great part in the form of a silicate, a similar conclusion to that which I have deduced from my examination of the sources of Caledonia. (See Journal de Pharm. et de Chim., t. vii, p. 15.

water, and I accordingly availed myself of the politeness of the proprietor, Mr. Wilkinson, who allowed me to take as much as I required, from a supply which had been brought from the spring a month previous, and preserved in well covered puncheons.

This was sensibly stronger to the taste than the water at the spring, and unlike the previously described waters, was disagreeably bitter, as well as saline. Its specific gravity was 1010·939.

A qualitative examination shewed the presence of chlorine, bromine and iodine, with potassium, sodium, calcium, and magnesium; a large portion of the latter two exist in the condition of chlorids. No sulphuric acid was detected; but traces of iron and alumina. Baryta, strontia, fluorine and phosphates were sought for; but with the exception of slight traces of the latter, the results were altogether negative.

1000 parts of the water of the Intermitting Spring afforded,

Chlorine	8·36979
Bromine	·02059
Iodine	·00187
Potash	·01930
Soda	6·49360
Lime	1·44930
Magnesia	·55467
Alumina and iron	traces.
Silica	·02250

These may be so combined as to give the following composition for 1000 parts of the water:—

Chlorid of sodium	12·250000
" of potassium	·030500
" of calcium	·287050
" of magnesium	1·033840
Bromid of magnesium	·023840
Iodid of magnesium	·002057
Carbonate of lime	·126460
" of magnesia	·863230
" of iron, Alumina	traces.
Silica	·022500
Carbonic acid	·501350
Water	984·859173
	1000·000000

The solid matter in 1000 parts, as determined by calculation, is 14·639 parts; the result obtained by directly evaporating a weighed quantity, and drying the residue at 300° F., was 14·500, the difference being probably due to a partial decomposition of the magnesian chlorid during the evaporation.

The carbonic acid of this water was not determined, as the fresh water, which was required for this purpose, was so much diluted as to be unlike the specimen analysed.

In a subsequent paper I purpose to describe some of the saline springs of the valley of the lower St. Lawrence, which are generally saline, and contain a greater or less proportion of earthy chlorids. The history of the mineral springs of the province when complete, will present some interesting relations to the geological structure of the country and the nature of the strata from which they rise.

Montreal, May 15, 1849.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Researches upon some derivatives of the Benzoic Series;* by G. Chancel, (Comptes Rend. des Travaux de Chimie, Juin, 1849, p. 177.)—The author has prepared the nitrobenzoic ethers of alcohol and wood-spirit, and confirmed their composition by analyses. He has found that they crystallize in right rhombic prisms of about 120°, and are consequently isomorphous. By the action of ammonia upon the vinic ether he obtained the nitrobenzamid which Mr. Field had before found by decomposing the nitrobenzoate of ammonia by heat. This body is sparingly soluble in water, above all in the cold, but dissolves readily in alcohol and ether, and crystallizes from them by slow evaporation in tables like gypsum. By a solution of potash it is decomposed with the evolution of ammonia, and yields nitrobenzoate of potash. When nitrobenzamid is dissolved in boiling water and hydrosulphuret of ammonia added in sufficient quantity, not the least trace of the amid separates on cooling. The liquid deposits a large amount of sulphur after standing a few hours, and by evaporation in a water bath to separate the last traces, the residue dissolved in water and filtered, gives by slow evaporation beautiful crystals which give on analysis the formula $C_7 H_{10} N_2 O_2$ (notation of Gerhardt). It loses an equivalent of water at 100° to 120° C., without undergoing any apparent alteration, so that its real formula, as is established by its compounds, is $C_7 H_8 N_2 O$.

This new substance no longer belongs to the benzoic series (C_7), but has disceded into the formic (C) and phenic (C_6) series, as will be seen by the results of its decomposition. It is a double carbonate of ammonia and aniline, *minus* the elements of two equivalents of water.

$$C H_2 O_3, C_6 H_7 N, H_3 N = C_7 H_8 N_2 O_2 + 2H_2 O.$$

The author has therefore called it *carbonilamid*. When gently heated with a mixture of lime and potash, it evolves in the form of ammonia exactly one half its nitrogren: if now the heat be considerably raised, pure aniline distils over and carbonate of potash remains. In the first stage of the process there is evidently the formation of a salt which if

not an *anthranilate*, is isomeric with it and the true *carbonilate*, which is then by an elevation of temperature decomposed into a carbonate and aniline. The action of sulphuric acid is equally characteristic; sulphanilic acid and sulphate of ammonia are formed with the evolution of carbonic acid gas.

$$C_7\,H_8\,N_2\,O + 2SH_2O_4 = CO_2 + C_6\,H_7\,N\,SO_3 + S(H, H_4\,N)\,O_4$$

This body sustains a close relation to *urea* which is truly *carbamid*; carbonilamid is urea in which the residue of an equivalent of aniline replaces that of one of ammonia. To represent this by the abbreviated formulas of M. Laurent,

$$Am = (H_3\,N + H) \qquad Am^{-2} = (H_3\,N + H) - H_2$$
$$An = (C_6\,H_7\,N + H) \qquad An^{-2} = (C_6\,H_7\,N + H) - H_2$$

Urea, (carbamid) ..... $C\,Am^{-2}\,A^{-2}\,O = C_2\,H_4\,N_2\,O$

Carbonilamid, ... $C\,An^{-2}\,Am^{-2}\,O = C_7\,H_8\,N_2\,O$

Like urea the new substance is readily soluble in water, alcohol and ether; the alcoholic solution decomposes spontaneously, but the watery solution gives fine colorless prisms of a fresh taste like nitre. The resemblance to urea is still farther shown by its action with acids, it is a veritable alkaloid and forms well defined crystalline salts. The nitrate, hydrochlorate and oxalate have been examined; the former is very sparingly soluble. It combines also with the nitrate of silver and the bichlorid of mercury; the chloroplatinate crystallizes in beautiful orange colored prisms. T. S. Hunt.

2. *On the Products of the dry distillation of Benzoate of Lime*; by G. Chancel, (Compt. Rend. des Trav. de Chim., March, 1849, p. 87.) —According to the researches of M. Peligot, the result of this distillation is a liquid, which he named benzone, and which corresponds to acetene, while carbonate of lime remains as a residue; he also recognized a portion of benzene and a hydrocarbon which he regarded as napthalene and which seemed to be secondary products of the decomposition.

But according to M. Chancel, the process is less simple and is always accompanied with the evolution of gaseous hydro-carburets during the whole process. When the dried salt is heated, the decomposition is complete at a temperature near low redness; along with the inflammable gases is obtained a brown liquid heavier than water. By distillation, a small quantity of benzene is separated; but the purification of the residue by this process was found impracticable. When submitted to the action of strong nitric acid, it evolves red vapors and ignites; if the action is now carried too far, a brown viscid mass results, insoluble in water; dissolved in a mixture of alcohol and ether and mixed with hydro-sulphuret of ammonia, the vessel after two or three days is found filled with magnificent golden yellow crystals. The same compound is obtained by dissolving the crude product of distillation in strong sulphuric acid, and after some days adding a little water until it becomes milky; the mixture on standing yields an abundant crust of this crystalline matter, which is even deposited in small quantities after a lapse of time from the crude liquid. It is consequently an original product of the decomposition of the benzoate; and its analysis, in whichever way obtained, gives numbers corresponding exactly to the formula $C_{13}\,H_{10}\,O$

(notation of Gerhardt), which is exactly the composition that theory assigns to benzone :—

$$2C_7 H_5 Ca O_2 = C O_2 Ca_3 + C_{13} H_{10} O.$$

Its claim to be considered as the acetonid of benzoic acid is shown by the fact that under the influence of potash-lime, it discedes at about 260° C. into benzoate of potash and pure benzene without evolving a trace of hydrogen gas or any other foreign substance.

$$C_{13} H_{10} O + KHO = C_7 H_5 KO_2 + C_6 H_6.$$

M. Chancel has given it the name of *benzophenone*, to show at once its relation to the benzoic and phenic series, while the termination recalls its place among the acetonids. It is insoluble in water but soluble in alcohol and ether; from a mixture of the two it is obtained by spontaneous evaporation in large transparent monoclinic prisms, of a slight amber tint. It fuses at 46° and boils at 315° C., distilling without alteration; its odor is fragrant, somewhat resembling benzoic ether.

Neither nitric nor sulphuric acids affect it in the cold; but fuming nitric acid by heat converts it into an oily liquid, which is dissolved by ether and deposited again almost immediately as a yellowish crystalline powder. This is *binitric benzophenone*, $C_{13} H_8 (N_2 O_4) O$ or $C_{13} H_8 X 2O$.

The product of the action of hydrosulphuret of ammonia upon this, is an alkaloid which had been some time before described by MM. Laurent and Chancel, under the name of *flavine*. The crude product of the distillation of the benzoate of lime, freed from benzene, was boiled several hours with fuming nitric acid and then diluted with water. The oily residue is mixed with ether, and after a time deposits a crystalline matter which was washed with a mixture of alcohol and ether. It is a mixture of binitric benzophenone, with some foreign matters which are very difficultly separable. By digestion in the cold with a mixture of hydrosulphuret of ammonia, alcohol and ether, the principal part is dissolved, and after twenty-four hours the vessel is filled with needles of the new alkaloid, which is purified by solution in hydrochloric acid, precipitation by ammonia and crystallization from alcohol. It forms fine needles, colorless or pale yellow, which are almost insoluble in water but dissolve in alcohol and ether. Fused with potash it disengages an oil possessing the properties of an alkaloid. Its formula is $C_{13} H_{12} N_2 O$. Its salts are soluble and crystallizable; the chloroplatinate is $C_{13} H_{12} N_2 O$, 2(Cl HP and Cl_2), a compound with two equivalents of the platinic chlorid.

These details respecting flavine are given in the Comptes Rendus des Trav. de Chimie for April, and the editors in a note announce that M. Chancel has found it to be in reality *carbanilid* or *anilic urea*. The details are promised in a following number. By referring to the account given above of carbanilamid by the same author, we shall see that while this is $C An^{-2} Am^{-2} O$, flavine is $C An^{-2} An^{-2} O = C_{13} H_{12} N_2 O$; the former being the substance intermediate between flavine and urea. The alkaline product obtained by the action of potash upon this new alkaloid will then be no other than aniline.

Among the products found in the crude liquid which yields the benzophenone, are two solid carbonates of hydrogen isomeric with naphthalene, one fusing at 92° and the other at 65° C.; the latter is obtained

with benzonitryl when the vapor of benzoate of ammonia is passed over ignited caustic baryta.

M. Chancel refers to the analogy pointed out by Gerhardt between the ethers and the products of the action of the mineral acids upon hydrocarbons;* as between nitrobenzene and nitromethol, sulphobenzenic and sulphomethylic acids. He has extended this view still farther, and shows that as nitrobenzene contains the elements of nitric acid and benzene, minus H_2O, so benzophenone is derived from the benzoic acid and benzene, minus the same elements. $C_7H_6O_2 + C_6H_6 = C_{13}H_{10}O + H_2O$. As the name of *phene* has already been given to benzene, which in reality does not belong to the benzoic series, M. Chancel observes that it will be well to apply to its derivatives the names of *nitrophenone* and *sulphophenone*, which will have the advantage of recalling their relations to benzophenone. T. S. H.

3. *On the Action of Nitric Acid upon Butyrone*, Laurent and Chancel, (Compt. Rend. des Trav. de Chimie, 1848, p. 174.)—The acid obtained some years since by M. Chancel, by the action of nitric acid upon butyrone, and by him named butyronitric acid, has been submitted to a new examination, from which it results that its formula is $C_3H_5NO_4 = C_3H_5XO_2$; it is consequently *nitrometacetonic acid.* The normal acid being $C_3H_6O_2$. It is insoluble in, and more heavy than water; has a very sweet taste and an aromatic odor. Its salts are crystallizable and explode by heat; that of potash forms yellow scales like iodoform. T. S. H.

4. *On Sulphuretted Benzamid;* by A. Cahours, (Compt. Rend. des Trav. de Chim., Avril, 1849, de Comp. Rend. de l'Acad., t. xxvii, p. 239.)—As the nitryls by fixing H_2O or $2H_2O$ yield amids or ammoniacal salts, M. Cahours was desirous to determine whether from the analogy between water and sulphuretted hydrogen, it might be possible to produce the corresponding sulphuretted compounds. On dissolving benzonitryl in slightly ammoniacal alcohol and saturating with H_2S, the solution became discolored, and after some time on concentrating by evaporation, a substance separated in yellow flakes, which dissolved in boiling water and crystallized by slow cooling in long sulphur-yellow needles of a satiny lustre. Analysis gave the formula C_7H_7NS, which represents sulphuretted benzamid. It is decomposed by red oxyd of mercury giving rise to water and sulphuret of mercury, and regenerating benzonitryl. Potassium decomposes it with the formation of a sulphuret and cyanid. M. Cahours proposes to pursue this interesting inquiry. T. S. H.

5. *On the Composition of Chloropicrine;* by A. Cahours, (Compt. Rend. des Trav. de Chimie, May, 1849, p. 171.)—In this Journal for May, 1849, p. 430, a new substance was described as discovered by Dr. Stenhouse by acting upon nitropicric acid by a solution of hypochlorite of lime. To this the discoverer assigned the formula $C_4Cl_7N_2O_{10}$. As this seemed quite anomalous, I proposed in its place, assuming the quantities of carbon and chlorine found to be correct, $C_4HCl_7N_2O_{10}$, and the more readily as his analysis actually gave a quantity of hydrogen amounting to one equivalent. M. Gerhardt remarking upon this

* Precis de Chimie Organique, tom. 1er, p. 154. See also this Journal for July, 1849, p. 90.

substance (Compt. Rend. des Trav. de Chimie, Fevrier, p. 34), suggested that its real formula is $C Cl_3 NO_2$, (corresponding to $C_2 Cl_3 NO_4$ in the ordinary notation,) and that it is *nitric chloroform* $C Cl_3 X$. This formula which requires carbon 7·2, chlorine 65, and azote 8·4, has been verified by analyses made by M. Cahours upon a pure specimen of chloropicrine, which has given him carbon 7·09–7·19; chlorine 64·59. M. Gerhardt calls attention to the close resemblance between the properties of this compound and that obtained by Marignac in action with nitric acid upon the chlorid of napthalene, which he has described in his Precis, as *forméne*, *bichloro-binitrique*, and which is represented by $C Cl_2 N_2 O_4 = C Cl_2 X_2$. T. S. H.

6. *Process for the use of Tin Plate Scrap in the Manufacture of Malleable Iron;* patented by Ed. Schunck, (Chem. Gaz., Aug., 1849.)—Large quantities of tin plate scrap accumulate in the manufacture of tinman's ware; these and worn out articles of the same material are useless except for small articles which are sometimes made from them. Their employment in the manufacture of wrought iron has been prevented hitherto by the presence of the tin; the present process is proposed for its removal.

A hot solution of alkaline persulphuret, for instance, persulphuret of sodium, obtained by fusing sulphur with carbonate of soda, converts the tin into sulphuret which is retained in solution, leaving the iron perfectly free from tin.

The same end is attained, although in a less perfect manner, by a solution of oxyd of lead in caustic alkali, or by alkaline chromate in the caustic alkali. The former, however, produced a deposit of metallic lead, the latter of chromic oxyd, and the removal of either of these is attended with inconvenience; the first process is therefore preferred.

The tin is removed from the solution by evaporation and crystallization; the mass when drained and pressed is dried and roasted in a reverberatory furnace; carbonaceous matter with dry carbonate of soda or quicklime is then added and the tin reduced. The slag resulting from this process contains an alkaline sulphuret, to which more sulphur may be added to form again the solution for stripping the tin plate.

The iron scraps from which the tin has been removed are washed and packed into sheet iron cylinders, which are raised to a welding heat and brought under the hammer, as in the manufacture of other scrap iron. G. C. Schaeffer.

7. *Anisole, Salicylic Ether, and substances derived from them;* by A. Cahours, (Comptes Rendus, Mar. and May, 1849.)—This investigation is another result of the fine discovery of Zinin, that hydro-sulphate of ammonia is capable of transforming the nitric compounds into true organic bases. This process was at first applied almost exclusively to the nitric compounds of the hydrocarbons; but other facts show its extension to compounds originally containing oxygen. This remark applies to the researches before us. The value of this extension of the process of Zinin is not trifling when we consider that many of the more important organic bases contain oxygen; we are therefore nearer than ever to the fulfilment of the promise long since made, of the artificial formation of quinine, morphine, &c.

From the distillation of balsam of Tolu, Deville obtained a hydrocarbon $C_{14}H_8$, which has been named a toluole; it is a homologue of benzole. This substance furnished Drs. Muspratt and Hofmann by the process of Zinin, a new organic base, toluidine, a homologue of aniline. Their paper in the Lond. and Edin. Phil. Mag., Sept., 1845, well deserves reading, and is particularly valuable for a tabular view of the parallel anisic and phenic series. Most of the compounds in the anisic series had been discovered or investigated by M. Cahours; the present investigation fills many of the gaps by supplying homologues of the phenic series, and in some cases, furnishes compounds without a parallel in the latter series. Still more, in the paper above mentioned, Drs. Muspratt and Hofmann announce a new base, nitraniline, being aniline in which one equiv. of H_7 is replaced by NO_4—a most remarkable discovery, for the entrance of the elements of peroxyd of nitrogen without effect upon the basic properties of the original substance. We shall presently see that three new bases of this singular kind have been discovered, anisole, which bears the same relation to toluole that phenole does to benzole, has already furnished bi- and trinitric species, in which 2H and 3H are replaced by $2NO_4$ and $3NO_4$. By acting upon anisole with fuming nitric acid and keeping the mixture cold, M. Cahours has succeeded in forming the *mono-nitric anisole*—an amber colored, aromatic, heavy fluid, boiling at about 505° F. This substance is readily decomposed by an alcoholic solution of hydrosulphate of ammonia; sulphur is deposited and a new base, *anisidine*, is formed, $C_{14}H_9NO_2$.

By a similar process, bi-nitric anisole furnishes a new base, differing from the last in having H replaced by NO_4, and is, notwithstanding the presence of the elements of a powerful acid, a true base capable of forming well defined crystalline salts with acids. *Nitric anisidine*, it may be called, $C_{14}H_8N_2O_6$, crystallizes in long reddish brown lustrous needles, insoluble in water, but readily soluble in boiling alcohol. Some of its salts are colorless when quite pure.

Fuming nitric acid forms with toluole a liquid mono-nitric, and a crystalline bi-nitric species. The former furnished with hydrosulphate of ammonia, toluidine, to Drs. Muspratt and Hofmann. The latter by the same reagent has given M. Cahours a new alkaloid, the *nitric toluidine*, $C_{14}H_8N_2O_4$, being toluidine with H replaced by NO_4.

Anisic acid with fuming nitric acid is found to form among other products, a new acid isomeric with tri-nitric anisole, and a homologue of picric acid. This substance, *chrysanisic acid*, $C_{14}H_5N_3O_{14}$, crystallizes from alcohol in beautiful golden yellow rhombohedral plates. It is distinguished from similar acids by giving a very soluble salt with potash.

The salycilic ether of wood-spirit (oil of wintergreen) forms a crystalline compound with bases, which furnishes on distillation, anisole. In like manner, Cahours has found that the salycilic ether of alcohol, forms crystalline compounds, and that of baryta on distillation gives a new substance, phenetole, $C_{16}H_{10}O_2$, a homologue of anisole. This, when acted upon by strong nitric acid, forms a binitric species, resembling binitric anisole, and probably also a trinitric species.

The alcoholic solution of the former with sulphuretted hydrogen and ammonia, forms *nitric phenetidine*, the homologue of nitric anisidine.

As the mono-nitric phenetole has not yet been obtained, we are without the original alkaloid phenetidine, of which the above is a derivative.

To render the relation of these remarkable substances more clear, we subjoin a table, containing also the previously known homologues.

I. Phenole $C_{12}H_6O_2$

Nitrophenesic acid / Bi-nitric phenole $C_{12}\left\{\begin{matrix}H_4\\2NO_4\end{matrix}\right\}O_2$

Picric acid. / Trinitric phenole $C_{12}\left\{\begin{matrix}H_3\\3NO_4\end{matrix}\right\}O_2$

II. Anisole $C_{14}H_8O_2$

Nitric anisole $C_{14}\left\{\begin{matrix}H_7\\NO_4\end{matrix}\right\}O_2$

Bi-nitric $C_{14}\left\{\begin{matrix}H_6\\2NO_4\end{matrix}\right\}O_2$

(Chrysanisic ac.) Tri-nitric anisole $C_{14}\left\{\begin{matrix}H_5\\3NO_4\end{matrix}\right\}O_2$

Anisidine, $C_{14}H_9NO_2$

Nitric anisidine $C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}NO_2$

III. Phenetole $C_{16}H_{10}O_2$

Bi-nitric phenetole $C_{16}\left\{\begin{matrix}H_8\\2NO_4\end{matrix}\right\}O_2$

Tri-nitric phenetole $C_{16}\left\{\begin{matrix}H_7\\3NO_4\end{matrix}\right\}O_2$

Phenetidine, (wanting.)

Nitric phenetidine $C_{14}\left\{\begin{matrix}H_{10}\\NO_4\end{matrix}\right\}NO_2$

IV. Benzole $C_{12}H_6$ | Aniline $C_{12}H_7N$ | Nitric aniline $C_{12}\left\{\begin{matrix}H_6\\NO_4\end{matrix}\right\}N$

V. Toluole $C_{14}H_8$ | Toluidine $C_{14}H_9N$ | Nitric toluidine $C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}N$

G. C. S.

8. *On the Compound Ammonias;* by ADOLPHE WURTZ, (Comptes Rendus, Aug., 1849.)—In the last number of this Journal (Jan., 1850, p. 65) Mr. Hunt has most clearly explained the mode of formation of this new alkaloid, and also their relation to a very interesting group of compounds. Since that paper was written, M. Wurtz has more fully described the properties of Methylamine and Ethylamine, and has also added a new ammonia to the series Valeramine.

Methylamine, as well as the other new alkaloid, may be obtained from its hydrochlorate by the action of zinc, just as ammonia is obtained from sal-ammoniac. Thus prepared, methylamine is a gas of ammoniacal odor, condensing into a liquid at about 32° F. Its density is a little greater than that of ammonia. It is the most soluble of all gases; at 53° F., one vol. of water dissolves 1040 vols.; at 77°, 959 vols.

In all its reactions, this substance can scarcely be distinguished from ammonia—it precipitates the same bases, e. g., magnesia, alumina, iron, lead, &c., and redissolves the same—zinc, copper and silver. The compound analogous to fulminating silver, however, does not detonate. Methylamine may be distinguished from ammonia by its burning with a yellowish flame. Its salts are generally soluble in absolute alcohol.

Ethylamine, by a freezing mixture is obtained as a caustic fluid, of ammoniacal odor, and boiling at 62° F. Its reactions are very similar to those of methylamine, but it does not form a precipitate with chlorid of platinum. It burns with a bluish flame.

Valeramine, the new alkaloid is obtained by the action of potash on cyanate of amylene (cyanic ether of fousel oil), the latter being prepared by distilling sulphamylate of potash in the cyanate of potash. Valeramine is a liquid with a burning bitter taste and ammoniacal odor; its solution in water produces the same reactions as above described, it redissolves the precipitate of salts of copper with more difficulty than the other ammonias; the same may be said of the solution of the chlorid of silver. The formula is $C_{10} H_{13} N$.

The strong resemblance of these new alkaloids to ammonia has undoubtedly caused their presence to be overlooked in many decompositions of nitrogenous substances. In a recent paper on the decomposition of caffeine by chlorine, Rochleder describes under the name of formyline, a new base to which is assigned the impossible formula $C_2 H_4 N$. This is undoubtedly methylamine, the analysis corresponding better with the composition of the latter substance, than with the above formula. Mr. Anderson has recently examined an alkaloid, petinine, $C_8 H_{10} N$, which in all probability is butyramine. We have then the following homologous series.

Ammonia,	$H_3 N$
Methylamine,	$C_2 H_5 N$
Ethylamine,	$C_4 H_7 N$
Butyramine,	$C_8 H_{11} N$ (Petinine, *Anderson.*)
Valeramine,	$C_{10} H_{13} N$

9. *On a Copper Amalgam;* by Dr. PETTENKOFER, (Ann. der Chem. u. Pharm., June, 1849, in Chem. Gaz.)—This remarkable compound, used by dentists for filling teeth, contains 30 parts copper and 70 parts mercury. As found in the shops, it is so hard as to require a powerful blow with a hammer to break it; the texture is crystalline. When heated to near 600° F., it swells slightly, and after trituration in a mortar, it becomes so soft on cooling that it may be moulded in the fingers like clay. In a few hours it again becomes hard enough to cut bone. Its density in the two conditions is so nearly the same, that if pressed into a glass tube while in the soft state, it becomes an air-tight stopper when hard. Many useful and less hazardous applications than filling teeth may be made of this curious substance.

Of several modes of preparation, the following appears to be the easiest and best. Finely divided copper obtained by precipitation by iron, is triturated in a porcelain mortar with protoxyd of mercury, me-

tallic mercury and boiling hot water. The mass from brittle becomes soft and plastic when enough mercury is taken up. The excess of mercury should be pressed out, and the cake allowed to harden, which takes more time, than after the second softening. G. C. S.

10. *Benzole;* by C. B. MANSFIELD, (Chem. Gaz., June, 1849.)—A useful application of coal naphtha, which is mainly benzole, was noticed in this Journal for June, 1849, p. 106. The author proposes a process for obtaining pure benzole in large quantities from coal tar. The light coal naphtha from coal tar, is to be distilled in a metallic retort or still, the head of which is surrounded by water—this rising to 212° and no higher, suffers the volatile substances of higher boiling point to fall back into the vessel, while the more volatile benzole passes over and is condensed as usual. By a second rectification, keeping the still head at a temperature of 176°, the benzole is obtained still purer. It is next agitated with one-tenth its bulk of strong nitric acid, poured off and again agitated with sulphuric acid. When redistilled, it may be further purified by cooling to 4° F.; the crystals pressed and afterwards treated with chlorid of calcium, furnish a pure article.

As benzole dissolves India rubber, gutta percha and most resins, it may be valuable for these purposes, for which, however, the crude coal naphtha is generally used. Its solvent power renders it, according to the author, a cheap and less volatile substitute for ether in the laboratory.

A large number of most interesting compounds, aniline, nitraniline, &c., may be obtained from this substance in great quantity, at but moderate cost. G. C. S.

11. *On the Separation of Phosphoric Acid from Alumina;* by H. ROSE, (Bericht der K. P. Akad. Wissensch. zu Berlin, 1849, 220; Chem. Gaz., No. 173.)—The author recently published a method* upon separating phosphoric acid from bases by means of mercury, which admits of the phosphoric acid being separated from most of the bases in such a manner, that not only its quantity can be determined with great accuracy, but that after its separation the bases can be readily examined and accurately estimated, without being contaminated by the substance used for separating the phosphoric acid. The proposed method gave unsatisfactory results with the presence of peroxyd of iron and alumina. When iron alone is present, it requires but a slight modification; but with the presence of alumina the difficulties increase to such an extent that the method becomes inapplicable.

It is however often of importance to be able to determine the phosphoric acid with accuracy in complex compounds which also contain alumina. In several rocks, especially in the basalts, salts of phosphoric acid occur, principally apatite; and undoubtedly the great fertility of a soil consisting of decomposed basalt is owing to the admixture of apatite.

When basalt is treated in the pulverized state with a dilute acid, this dissolves the apatite, together with the constituents of the decomposed zeolitic mineral soluble in acids, among which alumina is almost always present. Now by means of the molybdate of ammonia, the acid solu-

* See this Journal, viii, 181, Sept. 1849.

tion can easily be tested for a small quantity of phosphoric acid, in order that when present, even in minute quantity, it may not be overlooked in the analysis.

After numerous experiments, the author has found the following method to be the most advantageous for analyzing quantitatively complex phosphatic compounds containing alumina. The phosphate is dissolved in an acid, nitric or hydrochloric acid; and after dilution with water, a sufficient quantity of carbonate of baryta added. After it has stood for a couple of days in the cold, having been frequently agitated, it is filtered and the insoluble residue washed with cold water. The filtered solution contains the bases which were combined with the phosphoric acid, excepting alumina, peroxyd of iron and other weak bases. These, as well as the whole amount of phosphoric acid, are thus completely precipitated. The dissolved baryta is removed from the solution by sulphuric acid. This is somewhat difficult when much lime is present. In the filtered solution the bases are determined according to the usual methods.

The insoluble residue contains the whole amount of phosphoric acid which was present in the compound, as well as the alumina and the peroxyd of iron. It is dissolved in dilute hydrochloric acid, and the baryta removed by sulphuric acid. The filtered solution is saturated with carbonate of soda, and evaporated to dryness; the dry mass is mixed with silica and carbonate of soda, and heated to redness. The calcined mass is digested in water, and carbonate of ammonia added to it, when a considerable amount of silica is precipitated; it is filtered. The filtered liquid contains the whole of the phosphoric acid; it is supersaturated with hydrochloric acid, then with ammonia, and the phosphoric acid precipitated as ammonio-phosphate of magnesia.

The insoluble residue is digested with muriatic acid and the whole evaporated to dryness. The dry mass is humected with hydrochloric acid, and the silica separated in the usual manner, after which the alumina and peroxyd of iron are determined.

12. *On the Atomic Weight of Silica;* by H. Kopp, (Liebig's Ann., lxvii, p. 356; Chem. Gaz., July 16, 1849, p. 271.)—The doubts entertained respecting the atomic weight of silicon and the composition of silica according to one of the three formulæ SiO, SiO_2 or SiO_3, have not been solved by the views which have hitherto prevailed on this subject, where in general the decision has been made to depend on the circumstance, that a particular series of compounds might be most simply represented, sometimes according to one, sometimes according to the other formula. A peculiar mode of conceiving this subject shows that, admitting the correctness of the analytical results of Pelouze, the atomic weight of silicon with H=1 is 21·3, and the formula of silicic acid SiO_3.

Kopp has deduced this result from the difference between the boiling-points of the chlorid and bromid of silicon. The possibility is sufficiently evident of deciding the question by this means from a number of determinations of the differences between the boiling-points of several chlorids and bromids, in which the chlorine, on the one hand, may be regarded as a substitute for the bromine in the corresponding bromid, thereby establishing how many degrees the boiling-point

rises or falls when, in any compound, chlorine is replaced by bromine, or *vice versâ*, bromine by chlorine. After determining the number of degrees which express this difference for the substitution of each atom of chlorine or bromine, it is possible, on the other hand, to conclude, from the difference between the boiling-points of a chlorid and the corresponding bromid, as to the number of atoms replaced. Now it results, from the comparison of the boiling-points of several bromids and chlorids, that the substitution of 1Cl by 1Br raises the boiling-point 32° Cent.; of 2Cl by 2Br, $2\times32=64°$; of 3Cl by 3B, $3\times32=96°$; while the boiling-point falls in the same proportion when, on the contrary, bromine is replaced by chlorine. Compare, for example, the boiling point of the following substances:—

		Boiling-point.
C_4H_5Cl	Chlorethyle, ...	+11°, Pierre.
C_4H_3Cl	Chloracetyle, ...	−18° to 15°, Regnault.
PCl_3	Chlorid of phosphorus . .	78°, Dumas, Pierre.

		Boiling-point found.	Calculated.
C_4H_5Br	Bromethyle	41° Pierre.	43°.
C_4H_3Br	Bromacetyle	Ord. temp.	14° to 17°.
PBr_3	Bromid of phosphorus . . .	175°, Pierre.	174°.

Several other comparisons enumerated by Kopp lead to the law above announced respecting the change in the boiling-point in substitutions of bromine and chlorine. It consequently follows, as above stated, that according as the boiling-point of a bromid, on comparison with that of its corresponding chlorid, is situated at 32, 64 or 96 degrees higher than in the chlorine compound, this latter must be regarded as containing 1, 2, 3 atoms of chlorine replaced by bromine. The boiling-points of the chlorid of silicon and of the bromid of silicon have been determined by Pierre, a most accurate observer, the first to be 59°, the latter to be 153°; the difference is 94°; whence it follows that in the bromid of silicon 3 atoms of bromine are substituted for 3 atoms of chlorine in the chlorid of silicon; that the first is $SiBr_3$, the latter $SiCl_3$, and that silica is therefore SiO_3; and consequently we must admit the atomic weight of silicon to be 21·3, H being assumed =1.

13. *On the Extraction of Mannite from the Dandelion;* by Messrs. Smith; with an Analysis of the Mannite, by Dr. Stenhouse. Communicated by Dr. George Wilson, (Proc. R. Soc. Edinb., ii, 223.)—Messrs. Smith stated that they had extracted from the dandelion, a large amount of a crystalline sweet substance, having all the physical characters of mannite. It was analysed by Dr. Stenhouse, and found to contain carbon, hydrogen, and oxygen, in the proportions which characterize the accepted formula for mannite; viz., $C_6H_7O_6$, so that it certainly was the substance it was supposed to be.

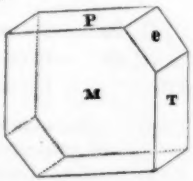
Messrs. Widumann and Frickhinger, it is stated, had anticipated Messrs. Smith in the separation of mannite from the dandelion juice, and were led to believe that the mannite did not preëxist ready formed in the dandelion; but was formed in the juice as the result of a peculiar fermentation which it underwent. This result was confirmed by the Messrs. Smith, who experimented with large parcels of the plant,

and found that even from quantities of the fresh root, so large as 40 lbs., no mannite could be extracted, if the expressed juice were prevented from fermenting; whilst, if fermentation were permitted, the same weight of roots yielded a large quantity of mannite, which appears to be derived from the sugar, inulin, &c., of the dandelion, which was converted into mannite, gum, and lactic acid.

The Messrs. Smith stated, in conclusion, that they had not been able to confirm the statement of Polex, that the dandelion contains a bitter crystallizable substance, such as he had described under the name of taraxacine.

II. Mineralogy and Geology.

1. *On Danburite;* by J. D. Dana.—The species Danburite, from Danbury, Conn., has recently been found, through the explorations of Mr. G. J. Brush, in crystallized specimens, which have afforded the following crystallographic and chemical characters.



Triclinic; P : M = 110° and 70°; M : T = 54° and 126°; P : T = 93° nearly; P : e = 135°. Cleavage distinct parallel to M and P, less so parallel to T. Crystals imbedded in feldspar, associated with dolomite, and often an inch across. Occurs also disseminated massive without regular form. H. = 7 – 7·5. G. = 2·95, Silliman, Jr.; 2·97, Brush. Color pale yellow or whitish. Lustre vitreous. Translucent to subtranslucent. Exceedingly brittle. The mineral resembles chondrodite somewhat, but differs in form and in its distinct cleavage, as well as chemical characters.

The chemical examinations of the species have been made by Mr. H. Erni, in the Yale Laboratory, New Haven. Before the blowpipe it fuses rather easily, and in the dark it is seen to give the flame a green color, especially after having heated the mineral with sulphuric acid. With bisulphate of soda and fluor spar the green color (a color due to boracic acid) is as distinct and strong as with borax. With borax or soda, a transparent glassy globule is easily obtained. The amount of the mineral under examination was so small that the boracic acid could be estimated only from the loss. Mr. Erni obtained—

	I.	II.	Oxygen ratio for I.		
Silica,	49·74	49·71	25·84		12
Lime,	22·80	22·38	6·48		
Magnesia,	1·98	1·30	0·78	10·50	5
Soda,	9·82	....	2·51		
Potash,	4·31	....	0·73		
Perox. iron and Alumina,	2·11	1·65			
Boracic acid (loss),	9·24	....	6·35		3
	100·00				

The ratio gives the formula $\dot{R}\ddot{B}+4\dot{R}\ddot{S}i$. The alumina is probably due to some feldspar, which is often detected penetrating the crystals.

Prof. Shepard, who described the mineral in this Journal, vol. xxxv, p. 137, obtained for its composition,

$\dot{S}i$ 56·00, $\dot{C}a$ 28·33, $\dot{A}l$ 1·70, $\dot{Y}t$ 0·85, $\dot{K}$ (with $\dot{N}a$?) and loss 5·12, $\dot{H}$ 8·0=100,

making it essentially a hydrous silicate of lime, a composition incompatible with the high degree of hardness. The presence of boracic acid accounts for this peculiarity.

2. *On the discovery of Sulphuret of Nickel in Northern New York;* by Dr. FRANKLIN B. HOUGH, A.M., with additional observations by S. W. JOHNSON, (communicated for this Journal.)—In January of the present year, while visiting my friend Dr. Hough at his residence in Somerville, St. Lawrence Co., N. Y., he showed me specimens of a mineral which from its physical characters he had decided to be sulphuret of nickel.

As its existence in the United States has not been heretofore reported, I communicate the substance of a notice he furnished me, in his own words—"This mineral has been found in limited quantities at the Sterling iron mine, in Antwerp, Jefferson Co., N. Y. It was first noticed by the writer about two years since, and attracted his attention from its delicate capillary appearance, brilliant lustre, and the difference of its crystalline form from that of sulphuret of iron, which in color and association it so nearly resembles.

"It occurs mostly in radiating tufts of exceedingly minute and slender crystals of a brass-yellow color, and very brilliant lustre, which when highly magnified present the appearance of flattened hexagonal prisms with striated faces, the striæ being parallel with the principal faces of the prism.

"No cleavage was observed, nor could the terminal planes of the prisms (if they possess any) be determined. When moderately magnified, the minute acicular crystals appear to gradually narrow to a point, but lenses of a higher power disclose the fact that these needles are composed of several crystals of unequal length united by one or more of their lateral faces.

"They occur in geode-like cavities of the iron ore, which are lined with crystallizations of spathic iron, specular iron, quartz, calcite, cacoxene, and sulphuret of iron; from among these crystals the tufts proceed, attached generally to the spathic iron, more rarely to the crystals of iron. It is not an abundant mineral; only perhaps one or two dozen specimens have been procured since its discovery."

In one elegant specimen in Dr. Hough's cabinet, a cavity of more than half an inch in diameter is traversed by six or eight somewhat parallel crystals of larger size than any other yet procured. Their diameter is about $\frac{1}{60}$ of an inch. These are attached, as are all the few larger crystals, by both extremities.

In a specimen which the writer procured of a miner, several crystals $\frac{1}{2}$ inch in length and $\frac{1}{80}$ of an inch in diameter, extended from side to side of the cavity, being irregularly disposed, and firmly attached to the spathic iron at each end. Inspection of the sectional surface formed by the breaking of the geode, led to the observation of minute crystals apparently springing from the iron, and traversing the spathic iron. In two instances a crystal was found completely transfixing a rhomb of spathic iron, and supporting it in air, at a distance of $\frac{1}{8}$ inch above the

inner surface of the cavity. In one of these cases, from the rhomb thus sustained, another needle of sulphuret of nickel projected upwards. These penetrating crystals are not in the least distorted. The larger ones of this specimen would admit of goniometrical measurement.

Chemical Examination.—A small fragment of one of the larger crystals heated in an open tube, evolved a strong odor of *sulphurous acid*. The roasted mineral which was black, but unaltered in form, was treated with hydrochloric acid, no action was manifest upon addition of nitric acid, and on application of heat, it quickly dissolved. The solution was evaporated to dryness, the residue dissolved and a drop of ferrocyanid of potassium added. The transparency of the solution was disturbed by a fine apparently white precipitate; an exactly similar result followed a parallel experiment, made upon a like quantity of a pure salt of nickel. This reaction is chiefly valuable as proving the absence of iron and copper.

A hot borax bead was brought in contact with a tuft of crystals. Some adhered. They melted in the oxydating flame, and dissolved in the borax, tinging it while hot, of a yellowish color, and upon cooling it appeared by reflected light, of a peculiar blackish shade, but colorless by transmitted light. In the reduction flame the glass after a time became gray and opaque. The blowpipe behavior of oxyd of nickel is differently stated in the books, but I have always observed the above phenomena with a certain rather slight degree of saturation.

The small quantity of mineral has precluded a more extended examination. Hereafter the associated specular iron, and spathic iron will be examined for nickel.

3. *New Mineral Localities in New York;* by Dr. F. B. Hough, (communicated for this Journal.)—*Pearl Spar*, has been discovered of a fine quality, in the town of Rossie, St. Lawrence county. It occurs in seams and crevices of white limestone, in a precipitous bank on the right side of the Oswegatchie river, and can be procured in considerable quantities.

Associated with this is calcareous spar, crystallized in the forms most common in the vicinity, viz., the scalene dodecahedron with the summits of the pyramids replaced by three rhombic faces. Another modification is common at this locality, in which the acute summit of the pyramids is replaced by a single hexagonal plane, perpendicular to the axis. The pearl spar is very white, and occurs crusting over the crystals of calcareous spar.

Idocrase, of a dark reddish brown color, and crystallized in the usual forms, occurs about a mile south of the village of Gouverneur, St. Lawrence county, in white limestone and associated with scapolite. The crystals attain a diameter of one or two inches, but the specimens which are best characterized are much smaller.

Sulphuret of copper, in limited quantities, has lately been discovered near Vrooman's Lake, in Antwerp, Jefferson county. Associated with this was fluor spar, and beautifully crystallized calcareous spar.

Sulphate of barytes, on the farm of Judge E. Dodge, in Gouverneur, St. Lawrence county, of a highly crystalline structure, and associated with fluor and calcareous spars. This locality is in the northwest part

of the town, about four miles from the village, and has been known about two years, although no account of it has (to the writer's knowledge) ever been published. It appears to exist in great abundance, in veins in sandstone rock, and may hereafter become of economical importance. It breaks readily in the direction of the cleavage, and specimens which have been exposed to decay, present an appearance not unlike that of a mass of nails, which have been partially fused, and melted together. Color when recently broken, pure white.

The same mineral has been discovered on the farm of Mr. R. Dean, in Antwerp, Jefferson county, about one mile east of the village of Ox-Bow. It occupies cavities in a coarse half decayed white limestone, is of low specific gravity, in consequence of numerous vermicular cavities with which it abounds, and occasionally presents botryoidal surfaces, studded with crystalline faces. From the presence of iron pyrites in small quantities, it becomes quickly stained with oxyd of iron, when exposed to the weather.

Stalactitic quartz, has been found in limited quantities at a newly opened pit at the Parish iron mine, in the town of Rossie, St. Lawrence county. The same has been found at the Sterling iron mine, in Antwerp, Jefferson county, with the surfaces beautifully encrusted with cacoxenite.

4. *A list of the Minerals associated with the Emery of Asia Minor;* by J. Lawrence Smith, (in a letter to one of the editors.)—Dr. Smith observes: I find associated with the emery,—calc spar; iron pyrites; octahedral and massive protoxyd of iron; magnetic iron ore; peroxyd of iron; hydrous peroxyd of iron; emerylite and other micas; sismondite or chloritoid (they evidently being the same mineral); diaspore; a mineral of waxy aspect having a similar composition to mica, being probably a kind of amorphous mica; a beautiful emerald green mineral, unalterable by heat and of considerable hardness, quantity in my possession too small to determine its character or composition; and black tourmaline. I do not allude here to the prismatic crystals of corundum, the massive blue corundum, as they properly constitute the emery.

5. *On the Degradation of the Rocks of New South Wales and Formation of Valleys*, (from the Geol. Rep. Exp. Exped., by J. D. Dana.)—The great depth, extent, and number of the valleys of New South Wales are calculated to excite wonder, and perplex us much in the study of their origin. In some of these sandstone regions, the gorges intersect the country in endless succession, with usually inaccessible precipices of one, two, or three thousand feet. They are deep gulfs, with walled sides composed of horizontal layers of sandstone. These layers seem once to have been continuous: and what is the force which has thus channelled the mountain structure? Are they "stupendous rents in the bosom of the earth?"* Are they regions of subsidence? Can it be that they were never filled, but were depressions left between the heaps of accumulating sediment that constitute the sandstone, which depressions were afterwards enlarged by the sea during the elevations of the land?† Or may we adopt the "preposter-

* Strzelecki's New South Wales and Van Diemens Land, p. 57.

† Darwin's Volcanic Islands, p. 137.

ous" idea, that simple running water has been the agent; and if so, was it fresh water, or the ocean?

The forms of these valleys are as remarkable as their extent. Major Mitchell states that Cox's River rises in the Vale of Clywd, 2150 feet above the sea, and leaves this expanded basin through a gorge 2200 yards wide, flanked on each side by rocks of horizontally stratified sandstone eight hundred feet high: here it joins the Warragamba. Some of its tributaries rise at a height of 3500 feet above the sea, and the ravines they occupy cover an area of 1212 square miles. From this he calculates that *one hundred and thirty-four cubic miles* of stone have been removed from the valley of the Cox.* The facts observed by us are sufficient to substantiate the general result, although we cannot add definite estimates of our own. The Kangaroo Valley is another example of a valley, two to three miles in width, and a thousand feet to eighteen hundred deep, opening outward through a comparatively narrow gap: and by a rough calculation from our own examinations, and the map of Major Mitchell, the amount of rock necessary to fill the valley is equivalent to a rectangular ridge, twelve miles long, two miles wide, and two thousand feet high. On the map of the Illawarra District, the form of this valley, (from the colonial surveys,) may be seen; and it is interesting as an illustration of the general character of these sandstone gorges, though wider than many of them in proportion to its length. This is but a small example, however, compared with those of the interior. Mr. Darwin remarks upon this peculiarity of form,—their extent and width and many branches, yet narrow openings at their lower extremity; and he observes that the same is the character of the bays along the coast.

In studying the origin of these valleys, we have then to consider the following particulars:—

1. Their high, precipitous, or vertical walls of stratified sandstone, and their flat areas at bottom—excepting where the descent of the stream is rapid.

2. Their frequent great breadth towards their head, while below, they are often very narrow, like a large bay with a small entrance.

3. The absence of all traces of the fragmentary material which could have filled these valleys.

The idea that running water was the agent in these operations appears not so "preposterous" to us, as it is deemed by Mr. Darwin; and we think it may be shown that Major Mitchell was right in attributing the effects to this cause. The extent of the results is certainly no difficulty with one who admits time to be an element which a geologist has indefinitely at command. But the subject admits of full explanation, as we believe, without making any improbable supposition on this point. We need but refer to a former page, in which we have discussed the subject of valley-making by denudation among the Pacific islands,† to show that New Holland, after all, is not the most remarkable land in the world for valleys of denudation.

We should consider that the rock material is far more yielding than that of basaltic Tahiti. Indeed the whole rock, from the uppermost layer to the deposits below the coal, is remarkably fragile, considering

* Expedition into Australia, ii. 352.

† See this volume, p. 48.

the age of the deposits,—crumbling readily, and often breaking without difficulty in the fingers; and besides, it is much fissured. Even the harder fossiliferous Wollongong rock has been described as sometimes falling to pieces of itself when exposed to the air. Moreover there are occasional clayey or argillaceous layers which are still softer; and many of those of the coal formation are not firmer than the material of a common clay bank. The denudation of such material requires no preparatory decomposition, as with many igneous rocks, but takes place from wear alone, and with but slight force in the agent.

It is obvious for the same reason that the material carried off by denudation ought not to appear in fragments through the lower country. A short journey along a rapid stream would reduce even large masses to powder. The plains of the Kangaroo Valley are covered in places with basaltic pebbles or boulders; but the sandstone, which is the prevailing rock along the bed of the stream and in the enclosing hills, has scarcely a representative fragment among the debris. The sandstone blocks are worn to sand or earth by the torrent, while the harder basalt is slowly rounded. On the plains of Puenbuen, similar facts were apparent. The hills contain sandstone and basalt, but only the latter appears as boulders or pebbles over the plains, or along the streams below.

This Sydney sandstone does not even require running water to promote degradation. In many caverns along cliffs, the rock gradually falls to powder by a species of efflorescence. There are numerous instances of this along the coves of Port Jackson, where the crystallization of the saline spray reduces the rock to its original sand; and in the interior of the country there are large caves, formed apparently by this same process, though probably from the crystallization of nitrates. Near Puenbuen, these caves are from six to twenty feet deep, and from four to forty long. The roof is arched, and appears to be constantly crumbling, while the bottom is covered with a fine dry ash-like sand, into which the feet sink several inches. The same operation is going on along the summits of the Illawarra range; and one huge block was found so hollowed out in this way as to be a mere shell, which sounded under the hammer like a metallic vessel.

These various facts bring before us some idea of the yielding nature of the rock which the waters have to contend with in the denudation of this country, and they also illustrate the various processes at work. We allude to a single other mode of degradation before passing: it is the action of growing trees and their roots, both in opening fissures and tumbling blocks down the precipices. It is a cause influencing very decidedly the characters of cliffs, and at the same time preparing the rock for decomposition and wear.

The credibility of the view we favor is farther sustained by the character of the streams. We have alluded to the great extent of the floods, and the rapid rise of the rivers attending them. The stream of the Kangaroo Grounds, when visited by the writer, was a mere brook, fordable in any part, and it flowed along with quiet murmurings. How different when the brook becomes a river thirty feet deep, driving on in a broad torrent, and flooding the valley; and this had been its condition but a few weeks before. If, as has been shown, the transporting

power of running water *increases as the sixth power of the velocity*, and a stream of fifteen miles an hour has more than ten times the transporting power of one moving ten miles an hour, and more than a million that of a stream two miles an hour,* we can comprehend how very inadequate must be the conceptions of this force which we derive from viewing a stream at low water.

This rise in the Kangaroo Grounds is an index of what takes place every few years over the whole country. Our surprise at the amount of degradation subsides before such facts; and we rather wonder that sandstones so soft and fragile, which have been exposed probably from the Oolitic period, still cover the surface to so great an extent as they do at the present time.

Mr. Darwin derives his principal argument against the hypothesis of denudation from the forms of the valleys,—their width, extent and ramifications, and yet *narrow* embouchures. But we find on consideration that this form is a necessary result of the mode of denudation under the circumstances supposed.

In our account of the valleys of the Pacific islands,† it has been shown that the gorges change their character where the slopes become quite gradual, from a narrow defile with convergent sides, to a broad channel with vertical walls and flat bottom: the cause of this change has also been explained. The same cause should produce a like effect in Australia. Though it be a repetition, we add in this place a brief explanation of the process. A stream, in making a descent of two or three thousand feet from the higher summits to the level of the sea, gradually deepens its bed by wear. Since the waters are increasing in quantity from various sources as they flow onward, this deepening of the gorge should be most rapid at its lower extremity; and it would continue in progress until the bed in that part became so low or gradual in slope, that the waters had lost to a large degree their rending force, and any excavation at bottom was made up by the material deposited along its course. This fact determines a permanent height for the bottom of the lower valley. As the stream continues its wearing action, in the same manner, the lower valley is gradually prolonged upward, retaining nearly the same slope at bottom (one or two feet to the mile); consequently the steeper portion of the gorge is at the same rate becoming shorter and still steeper. Thus the head of the stream may finally become a series of cascades, or, as it happens at times in the Pacific, it may be reduced mostly to a single cascade of a thousand feet or more.

The progress of this change may be better understood from the cut here given.

* Wm. Hopkins, *On the Transport of Erratic Blocks*, Trans. Camb. Phil. Soc., viii, 1844, p. 221.

† p. 379 of this Report; also this volume, p. 57.

A B C D is the rock to be cut through by the stream. Suppose denudation to produce first the course $C\,n^1$. The stream is filled, as is commonly the case, by lateral channels and rills down the sides of the gorge, as well as by the main source; and the amount or depth of water is thus in constant increase, as it flows onward. Denudation is consequently most rapid the farthest from the head, or towards n^1; the valley, therefore, increases in depth in this part till the slope has become so gentle here as to counterbalance the greater amount of water, at which point the bottom of the valley ceases to deepen; in this condition $n^1\,n^2$ becomes the bottom of the lower valley, and $C\,n^2$ the steeper portion above it. In the same manner the valley bottom continues to prolong at nearly the same slope, and $C\,n^3$, $C\,n^4$, $C\,n^5$ become successively the course of the stream descending into it. And even $C\,n^6$, is no exaggeration of possibilities; for many examples of it are met with.

But the results explained are but a part of the actual course of things in these regions of horizontally stratified rock. As on Oahu and elsewhere, when the denudation at bottom has reached its limit, the waters exert but little degrading power except during floods, and this takes place by the sides of the overflowing stream; at the same time, depositions of detritus take place along its banks. The result is that the rocks bounding the valley are worn away below, and are often undermined, as before explained; the valley widens at bottom to a flat plain, while the enclosing wall by the process becomes nearly vertical. A narrow riband of land between high precipices of rock is therefore a necessary result of the action.

Degradation still continues along the upper or steep part of the main stream, and also along the many streamlets and rills pouring down the valley's sides; and in each of these streamlets there is a tendency to produce below a flat-bottomed valley. The consequence is, that they increase the width and extent of the main valley-plain; for whenever they become thus flat-bottomed, they contribute to its lateral enlargement. At the same time, the bluffs at the lower extremity or embouchure of the main valley remain without much change, as the denudation is mostly confined to the vicinity of the streamlets alluded to, and these streamlets are most abundant above, since they are produced and fed chiefly by the rains in the higher part of the mountains. It is natural enough, therefore, that the valleys should not only become flat below and precipitous in their sides, but also that they should widen least at their lower extremity. We see, therefore, no necessity of appealing to any other cause than simply running water to account for the most stupendous results in Australia.

It has been supposed that the sea has been largely concerned in the denudation which has produced the Australian valleys. On this point enough, perhaps, has already been said on a former page. We find no reason for attributing any of the valleys to this source, although it is possible that some modifications may thus have resulted. The facts at Port Jackson are a sufficient reply on this point. The cliffs of the estuary actually undergo very little change from the action of its waters, and are far more altered by the mode of efflorescence described, and by rills of running water; and such action as is exerted, tends to

remove the headlands instead of deepening the coves. There is, therefore, good reason for believing that such estuaries as Port Jackson and Macquarie were dug out by fresh waters, and have since been submerged. The fact that there is a correspondence in trend with the fissures of the sandstones, shows that their direction was determined by these fissures, or by faults which have the same origin. We have remarked that the rock has not the same dip in the two Heads of Port Jackson, a fact indicating the existence of one or more intermediate faults.

III. Zoology.

1. *Report on Zoophytes;* by James D. Dana, Geologist of the Exploring Expedition under Captain Wilkes, U.S.N. 740 pp. 4to, 1846; with an Atlas of 61 plates in folio, mostly colored, 1849.—The publication of this work has been briefly announced in this Journal. The number of species of corals collected in the course of the voyage of the expedition was quite large, and it consequently became necessary to revise this department of science throughout; the volume therefore includes all known species of existing coral zoophytes, up to the date of its publication. The species added by Mr. Dana, or described anew from specimens examined, are in all cases indicated in connection with the mention of the locality; and moreover, in the catalogue of species accompanying the remarks upon each genus, the new and redescribed species are designated by an asterisk, in order that the observations for which the author is not personally responsible, may in all instances be readily obvious. The references and synonymes have been collected from a consultation and study of the original authors in this department, and not simply from the systematic treatises. There has thus been a complete revision of the synonymy of the science, besides a corrected identification of the species described or figured by former writers.

Out of the 444 known species of coral zoophytes, (excluding the Alcyonaria,) 233 are new species first described by the author; and of the remaining 211, 122 are redescribed from specimens. To the genus Madrepora, previously numbering 20 species, 52 new species are added, and 12 of the old species redescribed from specimens. The 30 known species of Astrææ were increased to 62; the four of Euphylliæ, D. (referred to Caryophyllia by Lamarck) to 15; the 17 of Fungidæ, to 60; the 57 of Madreporidæ to 141, and 34 out of the 57 old species were redescribed from specimens. This addition of species rendered it necessary to describe the old genera in some instances with more precision, and the examinations of the animals made it in general possible to give these descriptions a *zoological* character, a course in which Ehrenberg had led the way. Thus the science, like that of mollusca, is at last rescued from being a mere systematical arrangement of animal secretions. Species hardly distinguishable in the corals were sometimes found very different in the animals. The Antipathes, supposed hitherto to belong with the Gorgoniæ, from a resemblance in mode of growth, (as the species of each group have a horny axis,) were shown to be zoologically related to the Madreporæ,—the

naked character of the tentacles and their number, *six*, being widely different from the same in the Gorgoniæ and other Alcyonaria, in which the tentacles are *fringed* with papillæ, and the number is *eight*. The Actiniæ usually separated widely from coral zoophytes, have received their true place, in close affiliation with the Astræidæ.

2. *A new genus of Orchestidæ;* by J. D. DANA.—In a synopsis of the genera of Gammaracea, in this Journal, volume viii, p. 135, three genera of Orchestidæ are mentioned, Talitrus, Orchestia and Allorchestes. We here add a fourth; and for the purpose of giving a fuller comparative view of the four, and correcting a misprinted word, we insert the generic characters for the group.

1. Pedes primi non cheliformes nec subcheliformes, articulo styliformi confecti; secundi sæpe subcheliformes, manu sive parvulâ et debili sive nullâ. Antennæ superiores basi inferiorum breviores.	*Talitrus* (Latreille).
2. *Talitro* pedes primos antennasque similis. Pedes *maris* secundi valde subcheliformes, manu grandi.	*Talitronus* (Dana).
3. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores basi inferiorum breviores. Maxillipedes apicem obtusi.	*Orchestia* (Leach).
4. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores breviores, basi inferiorum longiores. Maxillipedes apicem unguiculati.	*Allorchestes* (Dana).

3. *On the Genus Astræa;* by JAMES D. DANA.—In the Report on Zoophytes by the writer, the Genus Astræa has the same extent nearly that was given it by Lamarck, but based on zoological evidence. It includes all those species of Actinacea in which the budding is from the summit and is a consequence of the gradual widening of the summit by growth: in some the budding resulting in a subdivision of the disk of a polyp; and in others, in the development of a new polyp from the widening parts just exterior to the disk, the widening not extending to the disk. The latter division had previously been separated by Ehrenberg and united with some other species, including one or two Gemmiporæ, to form his genus Explanaria, a Lamarckian generic name but with a wholly new application.

The author has shown that the budding and growth of the Gemmiporæ is essentially different from that of the Astræoid species here alluded to—in the former, the buds being *lateral* from towards the base of the polyps, while in the latter (as in Astræas) the *summit* of the polyps gradually widens or extends and produces buds. The corals of this species show this difference in a striking manner.* Rejecting, therefore, the genus Explanaria, (a name objectionable on account of its double use, as well as its etymological incorrectness,) the author retained the Astræoid species in the genus Astræa and introduced the subdivisions, corresponding, of Orbicella† and Fissicella, the latter including the species which increase by a subdivision or fission of disks, and the former those whose buds were marginal or interstitial.

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* See this Journal [2], iii, 16, 18.

† Corresponds to Blainville's subdivision *Tubastræa*, a name of hybrid origin.

Professor Agassiz has made some recent observations on the ova and development of a species of Actinia, and has shown that the number of tentacles in the young animal is at first *five;* and he has consequently inferred that this is a typical or normal number for the true Actiniæ. The Actiniæ, it should be observed, are identical with the ordinary coral polyps in all points of structure, and this number should therefore be expected to occur among them.

But the author has elsewhere shown* that in the Orbicellæ the number of tentacles is a multiple of 6 or 4. In the *Orb. argus*, *glaucopis*, *curta*, the number is forty-eight; in the *coronata* and *rotulosa*, thirty-six; in the *pleiades*, *hyades*, *excelsa*, *annularis*, *stellulata*, *microphthalma*, *ocellina*, twenty-four; in the *stelligera*, eighteen. The number *six* is likewise characteristic (perhaps sometimes *four* and not *six*) of the species of the genus Caryophyllia and other Caryophyllidæ; also of the Madreporidæ in which the number is *twelve;* and of the Antipathidæ, in which it is *six*.

From these different observations we therefore seem to have two typical numbers in the same group of animals. Prof. Agassiz's observation is sustained by the fact that many Actiniæ have a five-lobed summit, or a five-lobed mouth.

It is therefore a very probable inference that those Astræidæ which bud by subdivision of the disk pertain to the five series, and owe to this in part the indefinite growth of the disk and multiplication of tentacles, and the consequent fission that takes place. While those of the six series, as far as direct observation has gone, have a fixed limit to the number of tentacles,—the even number *six* being a limit-number, while *five* may or may not be so. The multiplication of tentacles as growth proceeds, has been shown by the writer to be quite analogous to the spiral development of the leaves or petals of a plant; and it is therefore an interesting fact that *five* should be the number for the unlimited spiral, while *six* is a limited spiral. This is a point, however, which direct observation on the young of the fissiparous zoophytes alone can fully establish.

From this and other considerations, the author concludes that the two subgenera of Astrææ are much more widely separate than is admitted in his system, as published in his Report. The Actinaria appears to contain two grand groups, one characterized probably by the number *five*, and multiplication by fission, while the other is characterized by the number *six*, and an absence of fission. The former includes the *Actinidæ* (excluding the Orbicellæ, Echinoporæ, and Phyllastrææ), with the *Fungidæ;* while the latter embraces—1. the *Orbicellidæ* (the species of the three genera just mentioned); 2. the *Cyathophyllidæ;* 3. the *Caryophyllidæ;* 4. the *Gemmiporidæ;* 5. the *Zoanthidæ;* 6. the *Madreporidæ;* 7. the *Antipathidæ*.

The subgenus *Orbicella* should therefore take the rank of a genus. We shall probably find that there are Actiniæ of both kinds, although hitherto not distinguished.

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* See Report on Zoophytes, p. 49, and this Journal [2], iii, 9.

As far as the writer has observed, none of the Palæozoic corals, or Cyathophyllidæ, bud by subdivision of disks. Some species have summit or disk buds; but these buds *grow out from* the disk, like those which grow from the sides; and are not a consequence of a gradual and successive multiplication of the tentacles and widening of the original disk, ending in a progressive subdivision. The nearest representatives of the ancient Cyathophyllidæ are to be found in the Orbicellæ and Caryophylliæ. But the transverse horizontal septa of many of the ancient species have nothing corresponding in these groups though represented among the Pocilloporæ and some other genera of recent Madreporidæ.

IV. Miscellaneous Intelligence.

1. *On the Extraction of Gold from the Copper Ores of Chessy and Sain-Bel;* by Messrs. Allain and Bartenbach, (Comptes Rendus, Nov. 19, 1849; Chem. Gaz., Jan. 1, 1850, p. 17.)—It results from our experiments, that at least two ten-thousandths of gold may be extracted from the above copper ores, the working of which, as the mines in question are of considerable extent, may become highly important. The density of the ore being 4, 1 cubic metre represents 800 grms. of gold. The operations are easy and rapid, and consist in first roasting the ore, and then dissolving out the gold.

After the mineral has been roasted in small fragments in the air, with a view to render it more friable, it is pulverized, passed through a fine brass sieve, and again roasted as much as possible, that is to say, until the powder has acquired a homogeneous brownish-red color. It is then formed into a paste with sulphuric acid of 66°, and roasted a last time until there is no further disengagement of sulphurous or sulphuric acid. The employment of sulphuric acid is most efficacious, as on the one hand, the sulphur in the form of sulphuric acid serves to remove sulphur, and on the other, as this metalloid, on becoming oxydized either by the air or at the expense of the oxygen of its compound, furnishes a greater amount of sulphuric acid than is wanted if the sulphurous vapors of the different roastings are passed into leaden chambers. Again, sulphuric acid is preferable for removing the oxyds of zinc and copper formed, as it readily converts the last traces of sulphurets which may have escaped the roasting into sulphates.

The substance is then reduced to as fine a powder as possible, and boiled with weak sulphuric acid. The insoluble portion is washed, and lastly heated with aqua regia diluted with water, but having been previously made in the proportion of 6 parts of hydrochloric acid of 21° and 1 part of nitric acid of 36°. This is an important point. The liquid containing the chlorids of iron, gold (and even of copper, for it is difficult to remove this metal entirely by a single ebullition with sulphuric acid), is placed in contact with iron, which precipitates the gold and copper; the precipitate is collected, washed, dried and calcined, to oxydize the copper. The gold may be separated from the oxyd of copper and oxyd of iron (for there is always a little of the latter precipitated in the cementation) by sulphuric or hydrochloric acid; but the separation, either by fusion or by chlorine or mercury, is prefera-

ble. With the chlorid the metal is reduced by heat, with amalgam the mercury is volatilized. The process above described is applicable to all pyrites which contain gold. The expenses attending the extraction of 2 lbs. of gold from the Chessy ores, after deducting the value of the copper obtained, do not exceed four hundred francs.

2. *The Table Land of Thibet*, (Athen., No. 1146.)—In April last we had occasion to speak of the first fruits of Dr. Hooker's mission to explore the botanical and physical character of the Himalaya. He had ascended the eastern extremity, within sight of the great snowy range, of which the peak Kinchin-junga, altitude 28,172 feet, is the loftiest yet known in the world,—and was anxiously waiting in the environs of Darjeeling, with the view of reaching the great table-land of Thibet, and determining the questions submitted to him by Humboldt relative to its elevation and snow lines.* Owing to the jealousy with which the frontiers are guarded by the Chinese and Sikkim tribes, and the difficulty of obtaining provisions and guides, it was some months before Dr. Hooker could make the pass. This, however, has been effected :—as the following letter describes.

Tungu, N.E. Sikkim, alt. 13,500 ft., July 25, 1849.

I have at length carried my point, and stood upon the table-land of Thibet, beyond the Sikkim frontier, at an elevation of 15,500 ft., at the back of the great range of snowy mountains. The pass is about ten miles north of this. We have Thibetan ponies, mounted thereon *à la Tartare ;* but I walked a considerable part of the way, collecting many new plants. The Thibetans come over the frontier in summer to feed their Yaks, and reside in horse-hair tents. I entered one and was much amused with a fine Chinese-looking girl, a jolly laughing wench, who presented me with a slice of curd. These people eat curd with herbs, milk, and Fagopyrum bread—only the richer can afford to purchase rice. They have two sorts of churn : one is a goat-skin, in which the cream is enclosed and beaten, stamped upon and rolled ; the other is an oblong box, a yard in length, full of rhododendron twigs, frosted with butter—and maggots. Some miles farther we reached the tents of Peppin, the Lachen Soubah, and were most graciously received by his squaw and family. The whole party squatted in a ring within the tent, myself seated at the head on a beautiful Chinese mat. The lady of the Soubah made tea, adding salt and butter, and each produced our Bhotea cup, which was always kept full. Curd, parched rice, and beaten maize were handed liberally round. Our fire was of juniper wood, and the utensils of clay, moulded at Dijarchi, except the bamboo churn, in which the tea, salt, and butter were churned previous to boiling. * * Presently a tremendous peal, like thunder, echoed down the glen. My companions started to their feet, and cried for me to be off,

* "Que je suis heureux d'apprehendre [says Humboldt] que vous allez pénétrer dans ces belles vallées de l'Himalayah, et même au-delà vers Ladak et les plateaux de Thibet, dont la hauteur moyenne, non confondue avec celles des cîmes qui s'élèvent dans le plateau même, est un objet digne de recherche. * * Eclaircir le problème de la hauteur des neiges perpétuelles à la pente méridionale et à la pente septentrionale de l'Himalayah en vous rappellant les données que j'ai réunies dans le troisième volume de mon Asie Centrale."

—for the mountains were falling and a violent storm was at hand. We pursued our way for five or six miles in a thick fog; the roar of the falling masses from Kinchin-jow on the one hand and Chomoimo on the other being truly awful. Happily, no fragment can enter the valley, by reason of the low hills which flank the river along whose bed we were journeying. Violent rain ensued, and drenched us to the skin. Gradually, as we ascended, the valley widened; and at the altitude of about 15,000 feet we emerged into the broad, flat table-land, composed of range after range of inosculating stony terraces, with a little herbage, amongst which the Lachen river meanders. Five hundred feet farther we found ourselves at the top of a long flat ridge, connecting the north-west extreme of Kinchin-jow with Chomoimo,—and here stood the boundary mark. Happily, the weather cleared. Northward the plateau dipped by successive very low ridges, overhung with a canopy of the vapors that had deluged us. Easterly was the blue sky and low ridges of the lofty table-land, which here backs the great range. To the west the spurs of Chomoimo and much mist veiled the horizon. Southeast Kinchin-jow, a flat-topped mass of snow, altitude 20,000 feet, rose abruptly from rocky cliffs and piles of débris. Southwest was Chomoimo, equally snow; while southward, between these mountains, the plateau dipped into the funnel-mouth head of the Lachen valley. Here I had an opportunity of solving the great problem—the Elevation of the Snow Line. Strange to say, there was not a particle of snow to be seen anywhere *en route*, right or left, nor on the great mountains for 1,500 feet above my position. The snow line in Sikkim lies on the Indian face of the Himalayan range, at below 15,000 feet,—on the Thibetan (northern) slope at above 16,000! I felt greatly delighted, and made a hasty sketch of the surrounding scenery:—somewhat rude, for at this great elevation my temples throb, and I retch with sickness.

Just above 15,000 feet all the plants are new; but the moment you reach the table-land nine-tenths of them disappear. Plants that are found at 12–13,000 feet on the Indian approaches to Thibet, did not ascend to the top of the Pass; still, as I always expected, at the turning point where the alpine Himalayan vegetation is to be soon replaced by Thibetan sterility, there is a sudden change in the *Flora*, and a development of species which are not found farther south, at equal altitudes in the Himalaya. We made a fire of Yak dung dried, and blew it up with bellows of goat skin, armed with a snout of Yak's horn. My poor Lepchas were benumbed with cold. I stayed an hour and a half on the Thibetan side of the frontier, and obtained good barometrical observations, and others with boiling water,—but the latter process is infinitely the more troublesome. On our return the weather cleared magnificently, and the views of the great mountains already named rising perpendicularly exceeded any that I ever beheld. For 6,000 feet they rise sheer up and loom through the mist overhead; their black wall-like faces patched with ice, and their tabular tops capped with a bed of green snow, probably from 200 to 300 feet thick. Southerly down the glen the mountains sunk to low hills, to rise again in the parallel of the great chain, twenty miles south, to perpetual snow, in rugged peaks. We stopped again at Peppin's tent for refreshment, and I again took horse. My

stubborn, intractable, unshod Tartar pony never missed a foot. Sharp rocks, deep stony torrents, slippery paths, or pitch darkness, were all the same to him. These ponies are sorry looking beasts; but the Soubah, who weighs sixteen stone, rode his down the whole thirty miles of rocks, stones, streams, and mountains; and except to stop and shake themselves like a dog, with a violence that nearly unhorsed me, neither his steed nor mine exhibited any symptoms of fatigue. Fever rages below from Choontam to Darjeeling. My people behave admirably, and I never hear a complaint; but I find it very hard to see a poor fellow come in, his load left behind, staggering with fever, which he has caught by sleeping in the valleys, eyes sunk, temples throbbing, pulse at 120, and utterly disabled from calling up the merry smile with which the kind creatures always greet me. We have little rain, but much mist; and I find great difficulty in keeping my plants in order. Do not be alarmed for me about fever, for I shall not descend below 6,000 feet. I have not been below 10,000 feet for the last two months. I lead a hard, but healthy life; and know not what it is to spend a lonely-feeling hour, though without a soul to converse with. Arranging and labelling plants, and writing up my journal, are no trifling occupation, and I am incessantly at work. JOSEPH DALTON HOOKER.

3. *On the Classification of Colors.* Part II. By Professor J. D. FORBES, (Proc. R. Soc. Edinb., ii, 214.)—The object of this paper is chiefly one of nomenclature. Every one has felt the difficulty of describing with precision the innumerable hues which occur in nature and in art; and which it is equally desirable for the optical philosopher, the artist, and the manufacturer, to be able to refer to in a clear and definite manner. But such a nomenclature or classification must proceed upon some admission as to the manner of compounding complex hues out of simple ones; and, therefore, the author first treats of the (so-called) Primary Colors. He admits it as highly probable, that all known colors may be formed out of red, yellow, and blue; although, when we attempt to compound pigments, we have a very notable loss of light, and also an unavoidable impurity, which is most visible in the compound tints. The author, in passing, endeavors to explain clearly why the union of pigments never can produce a perfect white, although the colored light of the spectrum does so; for, by adding blue light to yellow light, we not only change the color, but we increase the illumination; whereas, by adding a blue to a yellow pigment, whilst we change the color, we at the same time reduce the luminousness of the surface, the blue particles being far less reflective than the yellow ones. Inferring from Newton's empirical rule, the quantities of red, yellow, and blue light, which should combine to make white light; and adopting Lambert's results as to the reflective powers of the brightest pigments, the author concludes, that the mean illumination of a disk put in rapid revolution, and containing colored sectors, will be 4·57 times *less* than if it reflected the whole incident light, or it will reflect only about *half* the light which white paper does under the same illumination, therefore it will appear relatively *grey* under any given external illumination.

The author then states, that the triangular arrangement of colors first proposed by Mayer, and farther carried out by Lambert, appears to

afford the clearest and truest mode of displaying at a glance the modification of color due to the varying proportion of the three primary elements. In this triangle, perfect red, yellow, and blue, occupy the three corners; and these colors graduate into one another, according to the simple law of the distance of any point in the triangle from the three corners. The sides of the triangle are occupied by binary colors or compounds, by two and two; the interior is occupied by triple compounds; and the centre of gravity of the triangle ought to be a neutral grey.

Hence it will appear, that any hue not purposely diluted with black or white, is composed of a compound of a binary color with neutral gray. Hence a convenient nomenclature suggests itself as follows: the first column containing the binary colors.

Red.	Greyish Red.	Grey Red.	Red Grey.	Reddish Grey.	Grey.
Orangish Red,	*	*			
Red Orange,	*	*	*		
Reddish Orange,	*	*			
Orange.	Greyish Orange.	Grey Orange.	Orange Grey.	Orangish Grey.	Grey.
Yellowish Orange,	*	*			
Yellow Orange,	*	*	*		
Orangish Yellow,	*	*			
Yellow.	Greyish Yellow.	Grey Yellow	Yellow Grey.	Yellowish Grey	Grey.
&c.	&c.	&c.	&c.	&c.	&c.

These colors are supposed to be of the standard or maximum attainable intensity.

They may be diluted with white on the one hand, forming *tints;* or with black, forming *shades.*

Mayer's triangle may be repeated with these modifications; but as the color tends to extinction, either in the direction of perfect blackness or perfect whiteness, the number of compartments in the triangles may be diminished as the dilution of the colors increases. Thus, the whole may be formed into a double pyramid of color, converging to white above and to black below.

The author has been much indebted to Mr. D. R. Hay, the ingenious author of the "Nomenclature of Colors," and other works, not only for specimens of colored papers formed by the actual mixture of the three primary colors, but also for many valuable suggestions, of which, in the course of this paper, he has freely availed himself.

It is the author's wish to be able to obtain a series of colored enamels complete, according to Mayer's and Lambert's classification. Some he has already obtained from the Vatican Collection, (of which he gives a short description,) and he hopes to render it more complete.

4. *New Process for extracting Sugar from the Sugar-cane;* by M. Melsens, (Phil. Mag., xxxvi, 62, from Gard. Chron., Dec. 15, 1849.) —The following account of the new and important method of extracting sugar from the sugar-cane, is abridged from the first of two long articles recently published in the *Courier de l'Europe.*

The great difficulty which has been experienced up to the present time in the preparation of sugar, has been owing to the rapidity with which, when dissolved in water, it alters by exposure to the air in hot climates. It must, however, be obvious, since the cells of the sugar-cane

are themselves full of sugar dissolved in water, and this solution can be kept for a long time in them, without undergoing any alteration at all, that if the same conditions which exist in nature could only be obtained in practice, there is no reason why an artificial solution of sugar may not be kept unaltered for a considerable space of time; or in other words, why water should not be used for the purpose of dissolving the sugar out of the crude juice expressed from the cane.

The difficulties, indeed, are not owing to the sugar or to the water, but to the air, and the ferments produced by its action on the crude sap of the sugar-cane. The object of M. Melsens was then, to exclude the air from the sap when extracted from the cane, and to prevent the formation of any ferments which might change the character of the saccharine matter. This he has succeeded in doing by availing himself of the well-known affinity of sulphurous acid for oxygen gas. Sulphurous acid, however, alone was found not to answer the purpose; the sulphuric acid, produced by the absorption of oxygen by sulphurous acid, acting on the sugar, converts it into grape-sugar. This difficulty has been overcome by using sulphurous acid combined with a powerful base, which, as the sulphurous acid is converted into sulphuric acid, combines with the latter and forms an insoluble salt.

The acid sulphites, and more especially the bisulphite of lime, were employed by M. Melsens for the double purpose of preventing fermentation by the action of the sulphurous acid, and of neutralizing the sulphuric acid as fast as it formed by means of the lime.

Sugar-candy dissolved in cold water containing bisulphite of lime, even in excess, crystallized entirely, and without undergoing any change, by spontaneous evaporation, at a low temperature. Several other experiments of the same nature, but differing in their details, always gave the same result; in each the sugar crystallized out by spontaneous evaporation, without any loss either in quantity or in quality, and without any appearance of molasses. In these experiments, the sugar dissolved in water, containing bisulphite of lime in excess, was boiled, and then left to evaporate, sometimes after being filtered, sometimes without any filtration at all.

From the experiments which M. Melsens has made with bisulphite of lime, it is probable that if a cold solution of this salt were to be poured on the sugar-cane grinder, so as to mix with the juice the moment it is expressed from the cane, the sugar might be kept for some time, and might be exposed to the heat necessary for its clarification without any sensible loss or deterioration.

But this same salt also possesses the property of coagulating, at a temperature of 212°, milk, white of egg, blood, and yolk of egg mixed with water. At a temperature of 212°, bisulphite of lime acts as a clarifier. It separates the albumen, caseine, and other similar azotized matters which are found in the sugar-cane. This separation is effected without appreciable loss in the quantity, or deterioration in the quality of the sugar.

Bisulphite of lime, moreover, rapidly and tolerably effectually bleaches the colored substances found in the sugar-cane; it prevents the formation of other colored matters produced by the action of air on the pulp of the cane; it also stops the production of those which are formed

during evaporation, and above all, of those which require for their development the joint action of air and a free alkali.

It seems that colored substances which, under ordinary circumstances, are formed spontaneously by the exposure of the pulp of the sugar-cane to the air, never make their appearance when bisulphite of lime is employed. By evaporating at a low temperature, bisulphite of lime mixed with—1, a common solution of sugar; 2, the crude sap of the sugar-cane; 3, the juice of beet-root; no coloration was produced. By an evaporation of the same substances at a high temperature, the coloration was scarcely visible; indeed, with red beet-root the color was completely destroyed, and the sugar obtained was perfectly white.

It seems, then, that bisulphite of lime can be employed in the extraction of sugar:—1st, as an antiseptic, preventing the production and action of any ferment; 2nd, as a substance greedy of oxygen, opposing any alteration that might be caused by its action on the juice; 3rd, as a clarifier, coagulating at a temperature of 212° all albuminous and other coagulable matters; 4th, as a body bleaching all pre-existing colored products; 5th, as a body opposing itself in a very high degree to the formation of colored substances; 6th, as a base capable of neutralizing any hurtful acids which might exist or be formed in the juice, and substituting in their place a weak inactive acid, namely, sulphurous acid.

M. Melsens is of opinion that sugar can be obtained from the sugar-cane with no other source of heat than a tropical sun, excepting only for the purpose of clarification; indeed, the bisulphite of lime prevents the crude juice of the cane, or the syrup obtained therefrom, from undergoing any changes; great rapidity in the process of crystallization, indispensable at present, becomes by using this salt unnecessary; and more than this, the quantity of sugar which is now lost in the bagasse, in consequence of the impossibility of washing it out unchanged, can be all collected by being dissolved in water charged with bisulphite of lime.

The only objection that can be made to the above process is, that the sugar obtained by means of bisulphite of lime has a sulphurous taste; this is true, but the taste is completely lost—1st, by crushing the sugar and exposing it to the air, whereby the little sulphite of lime which there may be is converted into a tasteless sulphate; 2nd, by exposing the sugar to an atmosphere containing ammonia; if this is done the sugar acquires a very agreeable flavor of vanilla, but is apt to become a little discolored; 3rd, by clarifying it until it loses ten per cent. of its weight; by this process a pure white sugar can be obtained, which will bear comparison with any sample produced at present. The last is the process recommended to be used on a large scale. The quantity of sugar fit for the market which can be obtained from the sugar-cane by adopting bisulphite of lime, as above recommended, is at least double that obtained by the usual processes.

In consequence of M. Melsens having made all his experiments on the sugar-cane at Paris, and therefore on a small scale, he is not able to state how bisulphite of lime can best be used in the large colonial sugar manufactories, but is compelled to leave the application of the principles on which his method depends to the intelligence of the manufacturers themselves.

In the preparation of beet-root sugar bisulphite of lime is quite as useful as in the extraction of cane-sugar; the way in which it is to be employed in the former is fully explained in the second article published in the 507th number of the *Courier de l'Europe*, to which we must refer those among our readers who desire any further information on the subject.

5. *Anniversary of the Royal Society of London.*—On St. Andrew's Day, 30th of November, the anniversary of this Society was held at Somerset House, the Earl of Rosse, President, in the chair. An able review of the progress of astronomical and physical science was delivered by the President, the obituaries of deceased fellows read, and the three honorary rewards in the gift of the Society were publicly bestowed. The Copley Medal to Sir Roderick Murchison for his masterly works on the Silurian System and Geology of Russia; one of the Royal Medals to Col. Sabine for his valuable magnetic observations; and the other Royal Medal to Dr. Mantell, for the important services rendered to geology by his various memoirs on the Iguanodon, &c., published in the Philosophical Transactions. We have great pleasure in observing that the two Vice Presidents of the Geological Society of London, received this most honorable reward the scientific Englishman can attain, at the same time; the one for his eminence as a Geologist, and the other as a Paleontologist: both Sir G. Murchison and Dr. Mantell were also elected into the new council of the Royal Society.

6. *Ray Society*, (Athen., No. 1142.)—The Sixth Anniversary of the Ray Society was held during the meeting of the British Association, at Birmingham. From the Report of the Council it appears that the Society keeps up the number of its members. During the past year this body published a fourth part of the great work of Alder and Hancock on the Nudibranchiate Mollusca, a volume of the Correspondence of Ray, and the first volume of a complete Zoological Bibliography, by Prof. Agassiz, assisted by Mr. H. E. Strickland. For the present year a volume of Reports and Papers on Botany is already published; and two illustrated works are in a state of great forwardness: the first, a Monograph on the British Entomostracous Crustacea, by Dr. Baird of the British Museum; the second, a Memoir on the British Freshwater Zoophytes, by Prof. Allman, of Dublin.

7. *Zoological Gardens, London*, (Athen.)—The total number of animals in the Zoological Gardens is 1352, of which 354 are mammalia, 853 birds, 145 reptiles. Sixty-five species were added during the past year. The total number of visitors for the year 1849 was 168,895, which is 25,265 more than in 1848, and 75,349 above the number in 1847.

8. *Mastodon angustidens.*—A nearly perfect specimen of this mastodon has been found about six leagues from Turin, in a bed of plastic clay containing fresh water shells and covered with sand. The skeleton is preserved in the Royal Museum at Turin and is one of the most perfect hitherto found in Europe.

9. *Development of Electricity by Muscular Contraction.*—The experiments of Du Bois Reymond have been repeated by Prof. Buff of Giessen with apparent success. In one trial, sixteen persons held each

other by moistened hands, and on all contracting simultaneously by the right, or the left arm, they formed as it were, a circuit of increased electromotive power. The effect on the needle was evident, and it was opposite according as the right or left arm was contracted: the direction of the current was always from the hand to the shoulder. It is essential that the muscular contraction should be increased or at least continued until the needle begins to return and then suddenly discontinued. The greatest deflection amounted to ten or twelve degrees.

10. *Influence of boracic acid in Vitrification*, (Comptes Rend., Oct. 22, 1849; Phil. Mag., Dec., 1849.)—MM. Maes and Clemandot have studied the effect of boracic acid in the manufacture of glass, and conclude that before long this material will be considered essential to the best glass for optical purposes. They have formed the glasses consisting of the borosilicate of potash and lime—of potash and zinc—of potash and barytes—of soda and zinc. These borosilicates are remarkable for their transparency and hardness.

OBITUARY.

11. Dr. Martin Gay, (in a letter to the Senior editor from Dr. C. T. Jackson, dated Boston, January 17th, 1850.)—It becomes my painful duty to announce to you the death of our much beloved friend, Dr. Martin Gay, who died of peritonitis on the 12th inst., at 1½ o'clock, P.M.

Dr. Gay was the eldest son of the late Hon. Ebenezer Gay, and was born in Boston on the 16th February, 1803, and at the time of his decease his age was 46 years, 10 months and 26 days.

He was educated at Harvard University. On leaving that Institution, he prosecuted his professional studies under the instruction of Dr. George C. Shattuck, an eminent practitioner in this city, and was graduated Doctor in Medicine on the 25th of August, 1826.

He was elected a Fellow of the American Academy of Arts and Sciences on the 14th of November, 1838.

In August, 1841, he received the degree of Master of Arts from Harvard University.

He was one of the original members of the Boston Society of Natural History, and filled successively the offices of Curator in Mineralogy and of Recording Secretary for several years.

In October, 1844, he was married to Miss Eleanor Allen, daughter of Frederic Allen, Esq., of Gardiner, Maine.

Dr. Gay was a successful practitioner of medicine, and occupied his leisure hours in chemical researches, and in the cultivation of the science of mineralogy. In analytic chemistry, especially in the department of medico-legal enquiry, he was regarded as one of our most faithful and accurate chemists.

His testimony in cases involving medico-chemical questions, was most implicitly relied upon in our courts of justice, and he was remarkable for the perspicuity and fairness of his evidence.

Devoted to the cultivation of science, he lost no opportunity for improving himself, and during his travels in Europe in 1842, he collected much valuable information and made the acquaintance of many distinguished chemists, mineralogists and geologists in France, Germany and Italy.

His moral character was held in the highest estimation by all who knew him. It was marked by integrity, kindness, courtesy, and a high sense of truth and honor.

His admiration of the true and beautiful in science, literature and the fine arts, was a distinguishing feature of his cultivated mind. Although naturally very amiable and mild in his manners, he was remarkable for his moral courage, and base or mean actions never failed to excite his indignation. Independent in his character, and relying on his own acute perceptions of truth, he cared little for the authority of others, when he was satisfied that they were in error.

As a physician he was beloved and respected by all who knew him, and his nice sense of professional honor, and his sincere regard for the rights of others, was well known and appreciated among his medical brethren. Our scientific friend is removed from among us, but he has left us a bright example in his pure and unspotted life, and in his noble devotion to the cause of science and of truth.

V. Bibliography.

1. *Report of a Geological Reconnoissance of the Chippewa Land District of Wisconsin, and, incidentally, of a portion of the Kickapoo Country, and of a part of Iowa and of the Minesota Territory*, made under instructions from the United States Treasury Department; by David Dale Owen, M.D., U. S. Geologist for Wisconsin. 134 pp. 8vo, with numerous lithographs and geological sections.—This valuable document is occupied by the Reports of Dr. Owen, and his assistant, Mr. J. G. Norwood. The two regions particularly examined were first, along the Mississippi; and second, the interior and Lake Superior districts. The results, though only preliminary to a complete survey, are of great interest, both geologically and economically, as is true of whatever comes from the distinguished geologist whose name appears at the head of the survey. The illustrations of rock scenery, from Dr. Owen's sketches, are full of life and character. We cite the following facts.

The Kickapoo mines are situated between the Mississippi and Kickapoo and are connected with a magnesian limestone of the same character with that of the Mineral Point district. The ore is a peculiar one. It is of a light green color, waxy lustre and fracture, and very brittle, and is disseminated through ferruginous earthy matter composed chiefly of brown oxyd of iron. An analysis afforded protoxyd of copper 25·0, insoluble silicates with a trace of oxyd of iron 8·3, carbonic acid 5·0, water 11·2, peroxyd of iron 48·7, protoxyd of manganese 0·2, alumina 0·6, carbonate of lime 0·8=99·8. The position of the ore and rock indicates that it was once enclosed in a fissure in the magnesian limestone; but by decaying and denuding influences, the wall on one side has been removed. The ore is easily reduced and yields about twenty per cent. of copper.

With regard to the physical features of the country of the Lower Magnesian Limestone, Dr. Owen observes:—"The constant theme of remark, whilst travelling in the region of the upper Mississippi occupied by the lower magnesian limestone, was the picturesque character of the landscape, and especially the striking similarity which the rock exposure presents to that of ruined structures.

"The scenery on the Rhine, with its castellated heights, has been the frequent theme of remark and admiration by European travellers. Yet it is doubtful whether it is not equalled in actual beauty of landscape, by that of some of the streams that water this region of the far west. It is certain that though the rock formations essentially differ, nature has here fashioned, on an extensive scale, and in advance of all civilization, remarkable and curious counterparts to the artificial landscape which has given celebrity to that part of the European continent.

"The features of the scenery are not, indeed, of the loftiest and most impressive character. There are no elevated peaks, rising in majestic grandeur; no mountain torrents, shrouded in foam and chafing in their rocky channels; no deep and narrow valleys hemmed in on every side and forming, as it were, a little world of their own; no narrow and precipitous passes, winding through circuitous defiles; no cavernous gorges giving exit to pent up waters; no contorted and twisted strata, affording evidence of gigantic uplift and violent throes. But the features of the scene, though less grand and bold than those of mountainous regions, are yet impressive and strongly marked. We find the luxuriant sward, clothing the hill slope even down to the water's edge. We have the steep cliff shooting up through it, in mural escarpments. We have the stream, clear as crystal, now quiet and smooth and glassy, then ruffled by a temporary rapid, or when a terrace of rock abruptly crosses it, broken up into a small romantic cascade. We have clumps of trees, disposed with an effect that might baffle the landscape gardener, now crowning the grassy height, now dotting the green slope with partial and isolated shade. From the hill tops the intervening valleys wear the aspect of cultivated meadows and rich pasture grounds, irrigated by frequent rivulets that wend their way through fields of wild hay, fringed with flourishing willows. Here and there occupying its nook, on the bank of the stream, at some favorable spot, occurs the solitary wigwam, with its scanty appurtenances. On the summit levels spreads the wide prairie, decked with flowers of the gayest hue; its long undulating waves stretching away till sky and meadow mingle in the distant horizon. The whole combination suggests the idea, not of an aboriginal wilderness, inhabited by savage tribes, but of a country lately under a high state of cultivation and suddenly deserted by its inhabitants; their dwellings indeed gone, but the castle-homes of their chieftains only partially destroyed, and showing, in ruins, on the rocky summits around. This latter feature especially aids the delusion; for the peculiar aspect of the exposed limestone and its manner of weathering cause it to assume a resemblance somewhat fantastic indeed, but yet wonderfully close and faithful, to the dilapidated wall, with its crowning parapet and its projecting buttresses and its flanking towers, and even the lesser details that mark the fortress of olden time.

"Bold exposures of rock, with a grassy bank beneath, such as are represented by the sketches, are, for the most part, only on the south and western sides of the hills; the northern and eastern declivities are more rounded and most generally overgrown with trees and shrubbery."

2. *The races of Man and their Geographical Distribution;* by Charles Pickering, M.D., of the Scientific Corps of the Exploring

Expedition under C. Wilkes, U.S.N., Commander; forming volume IX. of the Reports of the Expedition. 450 pp. 4to.—This volume is the result of a vast amount of research by one peculiarly well fitted for observation by his habitual accuracy and his experience as a Naturalist. Dr. Pickering, after four years exploration in the Expedition around the world, made a journey to Egypt, Persia and Hindoostan to complete his observations. The range of the work will be gathered from the subjects of the chapters which we here mention. 1. On the Races of Man; 2. Explanation of the Map, illustrating their distribution; 3. the Races of America; 4. the Malayan Race, including the Polynesian; 5. the Australian Race; 6. the Papuan, including the Feejees; 7. the Negrillo Race of the East Indies, New Hebrides, &c.; 8. the Telingan or Indian Race in Hindoostan, &c.; 9. the Negro Race, Africa; 10. the Ethiopian Race, Nubia, &c.; 11. the Hottentot Race; 12. the Abyssinian Race; 13. the White or Arabian Race; 14. the Associations of the Races and Numerical Proportions; 15. Relations between the Races; 16. The Geographical Progress of Knowledge; 17, 18. Migrations by sea and by land; 19. Origin of Agriculture; 20. Zoological deductions; 21 to 24. Introduced Animals and Plants of America—of the Islands of the Pacific—of Equatorial Africa—of Southern Arabia; 25. Antiquities and introduced Plants and Animals of Hindoostan; 26. Introduced Plants and Animals of Egypt, enumerated in chronological order.—Dr. Pickering's extensive knowledge of botany and zoology has enabled him to collect together a vast amount of information in these closing chapters, and to correct or elucidate the meaning of many of the names of plants and animals in Greek and Arabic, which are often mistranslated in our Lexicons, and which in some cases were misunderstood by the translators of the Bible.

3. *Elements of Natural Philosophy*, designed as a Text-Book for Academies, High Schools and Colleges; by Alonzo Gray, A.M., Prof. Chem. and Nat. Phil. in the Brooklyn Female Academy, and Author of Elements of Chemistry, &c. 406 pp. 12mo, with 360 wood-cuts. New York. Harper & Brothers. 1850.—The author of the work before us has prepared a very convenient and well arranged work on the different departments of Natural Philosophy. He has condensed a widely extended subject into a small compass well fitted for the student. The work commences with the general properties of matter, and the forces which govern it, and then passes to the subject of motion, the mechanical powers, hydrodynamics, pneumatics including meteorology, sound, heat, steam, electricity, galvanism, magnetism and light or optics. Galvanism is here in its right place with other branches of physics.

4. *Sailing Directions;* by Lieut. M. F. Maury, U.S.N., National Observatory, Washington, published by authority of Commodore Lewis Warrington, Chief of the Bureau of Ordnance and Hydrography. 20 pp. 4to. Washington. 1850.—Lieut. Maury in this paper has made out a series of directions for navigating the different oceans, especially with regard to selecting the route for sailing. There are several tables containing specific information on this point for different latitudes and longitudes. These tables relate particularly to the route from New York to clear St. Roque, Brazil, and also to the routes to Europe and the return.

5. *The Plough, the Loom and the Anvil;* T. S. SKINNER, Editor.—This monthly periodical of practical and economical science, comes to us full of information and ably digested articles, original and selected. The first article in the January number before us, treats of the Harmony of Interests, Agricultural, Manufacturing and Commercial, in the United States, and is by H. C. Carey. It surveys the products of the country in these different departments with much valuable statistical detail, stating in tables the productions for successive years, of iron, coal, lead, woollens, &c., &c., and also illustrating the same by means of diagrams; and exhibiting a wide comprehension of the interests of the country in its various economical departments. Cotton Mills by Cotton Growers, Irish Peat, Charcoal and Sanitary Reform, are the subjects of other papers; and besides these, there are many shorter articles of practical value to the farmer and mechanic.

6. *Iconographic Encyclopædia of Science, Literature and Art*; by G. HECK, translated and edited by Prof. SPENCER F. BAIRD.—Rudolph Garrigue, New York.—The plates of Part V. of this Encyclopædia, the last which has reached us, are devoted to illustrations of the departments of Reptiles and Birds. The sketches are forcible and characteristic, illustrating the habits and haunts of the animals as well as their forms.

7. *Foster's Geological Chart.*—It has been represented to us that the Geological Chart noticed in our last number had not been finished, —although the copy received was varnished and mounted in the usual finished style; and that therefore it was not a fair subject for criticism. A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather has been shown us by the author. It has undergone important changes, though not all we should wish to see made. Figures of American fossils have been substituted to a considerable extent for foreign; misplaced fossils in the formations and the succession of rocks have been set right, and the names of the New York series of Rocks have been introduced,—together with the *Taconic formation* of Professor Emmons.

8. *The Annual of Scientific Discovery*, or Year Book of Facts in Science and Art, edited by DAVID A. WELLS, of the Lawrence Scientific School, Cambridge, and GEORGE BLISS, Jr.—We would call attention to the notice of this work on our advertising sheet. It is to be issued in the month of March, in a duodecimo volume of 350 pages. The Prospectus which has been sent us, bears high testimonials from Professors Agassiz, Horsford, Wyman and Gould, of Cambridge.

Agassiz's Lake Superior, is also soon to be issued, from the same house in Boston, and we doubt not it will be sought for with avidity. The high importance of the work, the peculiar interest of the region, and the eminent attainments of the author, must give these results of Prof. Agassiz and his able coadjutors a wide distribution over both this country and Europe.

9. *The Astronomical Journal*, Cambridge.—Nos. 3 and 4, for January 7, and February 2, 1850, contain—Observations of Metis, by *Mr. James Ferguson.*—Observations of Metis, made at the Hamburg Observatory, by *Prof. Charles Rümker.*—On the Phenomena attending the disappearance of the Rings of Saturn, by *G. P. Bond.*—On the

Heliocentric place of Neptune, by *George W. Coaklay*.—Note on the parallelogram of Forces, by *Prof. Peirce*.—On the orbit of the Great Comet of 1843, by *Prof. J. S. Hubbard*, (continued).—Development of the Perturbative Function of Planetary Motion, by *Prof. B. Peirce*.

10. *Journal of the Academy of Natural Sciences of Philadelphia*.—Part IV, which is just issued, completes the 1st volume of the new series in 4to, (pp. 356.) We give here the contents of the volume.

Part I. Dec. 1847.—1. Robert W. Gibbes, M.D., on the fossil genus Basilosaurus, Harlan, (Zeuglodon, Owen,) with a notice of specimens from the Eocene Green Sand of South Carolina.

2. M. Tuomey, State Geologist of South Carolina.—Notice of the discovery of a Cranium of the Zeuglodon, (Basilosaurus.)

3. Richard Owen, Esq., F R.S.—Observations on certain fossil bones from the collection of the Academy of Natural Sciences of Philadelphia.

4. John Cassin.—Description of a new rapacious Bird in the Museum of the Academy of Natural Sciences of Philadelphia.

5. William Gambel.—Remarks on the Birds observed in Upper California, with descriptions of New Species.

6. Joseph Leidy, M.D.—(1.) History and Anatomy of the Hemipterous Genus Belostoma. (2.) Miscellanea Zoologica.

7. J. L. Le Conte, M.D.—Fragmenta Entomologica.

Part II. August, 1848.—8. S. S. Haldeman.—Descriptions of North American Coleoptera, chiefly in the Cabinet of J. L. Le Conte, M.D., with reference to described species.

9. T. A. Conrad.—Observations on the Eocene formation, and descriptions of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Mississippi; with an Appendix.

10. John Cassin.—Description of a new *Buceros*, and a notice of the *Buceros elatus*, (Temm.,) both of which are in the collection of the Academy of Natural Sciences of Philadelphia.

11. John Cassin.—Descriptions of three new species of the genus *Icterus*, (Briss.,) specimens of which are in the Museum of the Academy of Natural Sciences of Philadelphia.

12. Robert W. Gibbes, M.D.—Monograph of the Fossil Squalidæ of the United States.

13. Thomas Nuttal.—Descriptions of Plants collected by William Gambel, M.D., in the Rocky Mountains and Upper California.

Part III. August, 1849. 14. Robert W. Gibbes.—Monograph of the Fossil Squalidæ of the United States.

15. T. A. Conrad.—Descriptions of New Fossil and Recent Shells of the United States.

16. T. A. Conrad.—Notes on Shells, with descriptions of new Genera and Species.

17. William Gambel, M.D.—Remarks on the Birds of Upper California, with descriptions of new species.

18. Samuel George Morton, M.D.—Additional Observations on a new living species of Hippopotamus.

19. John Cassin.—Descriptions of new species of Birds of the genera *Vidua*, Cuvier, *Euplectes*, Swainson, and *Pyrenestes*, Swainson,

specimens of which are in the collection of the Academy of Natural Sciences of Philadelphia.

20. S. S. Haldeman.—Cryptocephalinarum Boreali-americæ diagnoses cum speciebus novis musci lecontiani.

21. Charles D. Meigs, M.D.—Observations on the Reproductive Organs, and on the Fœtus of the Delphinus Nesarnak.

Part IV. January, 1850. 22. T. A. Conrad.—Description of new Fresh Water and Marine Shells.

23. Spencer F. Baird, Carlisle, Pa.—Revision of the North American Tailed-Batrachia, with descriptions of new genera and species.

24. John Cassin.—Descriptions of new species of the Genera *Micrastur*, G. R. Gray, *Tanagra*, Linn., and *Sycobius*, Vieill.

25. Robert W. Gibbes, M.D.—New species of Myliobates from the Eocene of South Carolina, with other genera not heretofore observed in the United States.

26. Joseph Leidy, M.D.—Descriptions of two species of Distoma, with the partial history of one of them.

27. John L. Le Conte, M.D.—An attempt to classify the Longicorn Coleoptera of the part of America north of Mexico.

11. *Memoirs of the American Academy of Arts and Sciences*, New Series, vol iv, Part I, 220 pp., 4to, with twenty-six plates. Cambridge. 1849. The following are the titles of the papers herein contained.

1. Asa Gray, M.D.—Plantæ Fendlerianæ Novi-Mexicanæ: An Account of a Collection of plants made chiefly in the Vicinity of Santa Fé, New Mexico, by Augustus Fendler; with Descriptions of the New Species, &c.

2. Charles Henry Davis, A.M., U.S.N.—Upon the Geological Action of the Tidal and other Currents of the Ocean. (With three Plates.)

3. S. S. Haldeman, A.M.—History and Transformations of Corydalus cornutus. (With a Plate.)

4. Joseph Leidy, M.D.—Internal Anatomy of Corydalus cornutus, in its three stages of existence. (With two Plates.)

5. William S. Sullivant, A.M.—Contributions to the Bryology and Hepaticology of North America. Part II. (With five Plates.)

6. William Cranch Bond, A.M.—Description of the Observatory at Cambridge, Massachusetts. (With six Plates.)

7. George P. Bond.—On some Applications of the Method of Mechanical Quadratures.

8. James Deane, M.D.—Illustrations of Fossil Footprints of the Valley of the Connecticut. (With nine Plates.)

The plates are of the first order of excellence. Those illustrating the transformations and anatomy of the Corydalus cornutus are of unrivalled delicacy, and the dissections by Mr. Leidy, who is distinguished for his skill in microscopic anatomy, are no where surpassed. The plates of fossil footprints by Mr. Deane are in a good style of lithography, and accurately represent the character of the impressions. The author figures some new species but without giving names. The article is an interesting sequel, if we may so consider it, to Pres. Hitchcock's elaborate paper in the preceding volume.

12. *Boston Journal of Natural History*, Vol. VI, No. 1.—The following is a list of the memoirs in this number:

I. E. Desor. Embryology of Nemertes and Embryonic Development of Polynöe.

II. N. M. Hentz. Araneides of the United States, with figures.

III. J. D. Whitney. Chemical Examination of some Minerals.

IV. J. D. Whitney. Examination of the Arkansite, Schorlomite and Ozarkite of Shepard.

V. S. L. Bigelow, M.D. Habits of Salmo fontinalis.

VI. W. O. Ayres. Description of a new genus of Fishes, Malacosteus.

VII. J. L. Le Conte, M.D. On the Pselaphidæ of the United States.

VIII. Samuel Kneeland, Jr. Dissection of Crocodilus lucius.

IX. T. S. Hunt. Chemical examination of the new mineral Algerite, with a description by F. Alger.

X. F. Alger. Examination of a Sapphire from Cherokee Co., Georgia.

XI. Jeffries Wyman, M.D. On the Cancellated Structure of the Bones of the Human Body.

Smithsonian Contributions to Knowledge.—Occultations visible in the United States during the year 1850. Computed by John Downes. 26 pp. 4to. *Washington*, 1849.

Prof. Bell: A History of British Reptiles, 2nd edition, with 50 wood engravings. 8vo. *London*, 1849. 12*s*.

L. L. Boscawen Ibbetson: Notes on the Geology and Chemical Composition of the various strata of the Isle of Wight, with a map in relief colored geologically. 8vo. *London*, 1849. 7*s*. 6*d*.

Prof. Owen: On Parthenogenesis, or the Successive Production of Procreating Individuals from a single Ovum. 8vo. *London*, 1849. 5*s*.

A. E. Knox: Ornithological Rambles in Sussex, with 4 lithographs. Post 8vo. *London*, 1849. 7*s*. 6*d*.

E. Forbes and S. Hanley: A History of British Mollusca; parts 13 to 24. 8vo. *London*. 2*s*. 6*d*. plain; royal 8vo, colored, 5*s*.

H. Doubleday: A Synonymic list of British Lepidoptera. 8vo. *London*, 1849. 2*s*.

Quarterly Journal of the Geological Society.—No. 19 of this Journal is occupied with a memoir by Murchison on the Alps, Appennines and Carpathians, 160 pages. No 20, contains a memoir on the Eocene of Hampshire by Mr. Moore; on a Siliceous Zoophyte by Bowerbank; on Platysomus by P. Egerton; on Neritoma by Mr. Morris; on the Gypsum of Plaister Cove by Mr. Dawson; on Footprints in Sand by Lyell; on the Crag at Chillesford, by Mr. Prestwich; on Erect Sigillariæ, with drawings of the roots by Mr. Brown; on the Geology of Asia Minor by Mr. Hamilton; on Tylostoma by Mr. Sharpe; on Fossil Reptiles of New Jersey by Prof. Owen, with a translation of Bronn's Palæontological Statics.

Transactions of the Royal Society of Edinburgh, vol. xvi, Part V, 1848–1849. —Art. 34. Biographical Notice of the late Thomas Chalmers; *E. B. Ramsay.*—35. Theory of rolling Curves; *J. C. Maxwell.*—36. An account of Carnot's Theory of the Motive Power of Heat, with Numerical Results deduced from Regnault's Experiments on Steam; *W. Thomson.*—37. On the Effects of Pressure in lowering the freezing point of Water; *J. Thomson.*—38. On the gradual production of Luminous impressions on the Eye and other Phenomena of Vision; *W. Swan.*

Makerstoun Magnetical and Meteorological Observations for 1845 and 1846. 420 and lxxii pages, 4to, with numerous Charts; forming volume xix, part 1, of the Transactions of the Royal Society of Edinburgh. Edited by John Allan Brown, Esq., director of the Observatory of Edinburgh. 1849.